ASTRO-PHYSICS

GTO KEYPAD CONTROLLER

Version v2.6

Future Upgrades

In the next few months, we will add a new feature to our web site which will allow future keypad upgrades to be accomplished through the internet. Check our web site www.astro-physics.com periodically for further information.

January 6, 2000

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ASTRO-PHYSICS

GTO KEYPAD CONTROLLER v2.6

The GTO keypad hand controller is the communication center for the operation of your GTO mount. We have designed this unit to be as intuitive and easy to use as possible while filling it with terrific features to make your observing session productive and pleasurable. With a few keystrokes, you can slew to objects by their common name or catalog number, set up search parameters to find all the open clusters (in the Messier catalog) that are visible on a given night, focus your telescope for astrophotography, set the countdown timer for the exposure, enter RA and Dec coordinates to find the newest super nova, and much more.

The heart of the controller is the 4-line display screen that will guide you through all operations. The alphanumeric keypad itself is translucent and backlit with red LEDs for easy visibility at night. Since the buttons are also fluorescent, it will glow in the dark for a brief time.

Each button is assigned to one function only. You do not have to remember shift key patterns or complex keystroke sequences. The directional buttons are shaped like arrows to help you find them in the dark without looking at your keypad. The stop button is readily accessible if you need to cancel any slewing request immediately.

The menu system is very easy to navigate. Each screen will display several choices, which correspond to a number button. Simply press the number button to initiate the command, e.g. “1=M, 2=NGC”. When you press “1” the Messier entry screen will display and you can enter the number of the object that you wish to see. Press GOTO, which will cause the mount to slew. The <PREV and NEXT> buttons will allow you to scroll quickly through the lists of common names or from one menu to another. To adjust most settings, you will press the number indicated on the screen several times to scroll (toggle) through your choices and stop at the one you want.

We suggest that even if you plan to slew to various objects using a computer program on a PC, you should use the keypad controller for your initial polar alignment/calibration routine. This will provide your mount with essential data regarding your location and time and will allow you to polar align with ease.

LAYOUT OF KEYPAD

Vacuum Fluorescent Display

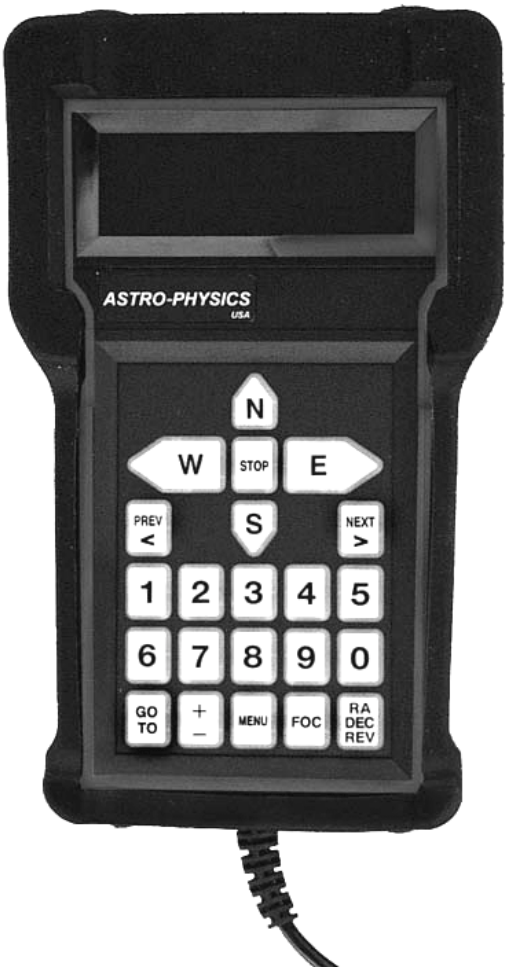
The keypad features a four-line, 20 character alphanumeric display. The brightness of the display is adjustable with “dim” and “bright” settings. Please refer to the section entitled “Adjust Brightness of Screen Display”. If you are using the keypad in the daylight, you may need to shade the screen from the direct light with your hand in order to see it more clearly.

N - S - E - W Directional Buttons

These four buttons are arranged so that the “E” and “W” buttons control the movement in right ascension and the “N” and “S” buttons control the declination. This is the “normal” orientation of objects in the eyepiece field. When you press the “N” button, the star should move in an upward direction toward the top of your eyepiece field. In addition, you can press two buttons simultaneously for diagonal movement, e.g. the “N” and “W” buttons will cause a “NW” movement.

RA/DEC REV Button:

If the star moves down when you push the “N” button, press the RA/DEC REV button in the lower right corner of the keypad. A reversing menu will appear on the screen. If you want to reverse direction of the “N” and “S” button, press “1” on the keypad and the display will change from “normal” to “reverse”. You can make the same adjustment with the “E” and “W” buttons. When properly set up, the direction buttons will cause the object to move according to your orientation at the eyepiece.



Keypad Controller shown with Keypad Protector

STOP Button

Press the STOP button to cancel a slewing command and stop the movement of the telescope immediately. The mount will know where it is, so you can proceed to your next command. If you move the telescope by hand, you must follow the recalibration procedure.

Number Buttons

The buttons labeled 1-9 and 0 are used to enter numerical data and to make menu choices.

<PREV and NEXT> Buttons

These buttons are used for the following functions depending on the commands you are entering: move from one menu level to another, backspace to make corrections to number entry or scroll through lists of objects. The “<“ and “>“ symbols appear on many screen displays. They signify that you can press the <PREV and NEXT> buttons for more choices. These buttons are also used in conjunction with the FOCUS button as described below.

GOTO Button

Press the GOTO button after you have selected the object that you want to view. The mount will slew to the object.

+ - Button

This button has two different functions. Use it to toggle between “+” and “-“ when entering RA and Dec coordinates.

Press this button to display a screen, which allows you to change the rate of the directional buttons. Use the <PREV and NEXT> buttons to increase and decrease the rate. You can access this feature whenever the directional buttons are active.

MENU Button

Press this button to move to a previous menu level.

FOC Button

To use this function, you must have an electric focus motor (available from JMI, Meade and others) plugged into the GTO Control Panel and the corresponding attachment to your focuser. Hold the FOCUS button with one finger and press the <PREV and NEXT> buttons to change focus. You can change the speed of the focus adjustment to either “High” or “Low”. Please refer to “Focus Adjustment“ on page 15 for further information.

Retractable Hanger

On the back of the controller, look for a slot with a thumb rest area. Push up to extend the hanger.

Keypad Protector

The keypad protector (part # KEYPRO) is a highly recommended optional accessory. It is a heavy-duty molded rubber casing with a full 1/4” thickness on all impact surfaces. If you accidentally drop your keypad, the rubber casing will absorb much of the blow. Your display, keypad, electronics and the case itself will be protected from damage. In addition, the rubber prevents the keypad from sliding when placed on a table or other flat surface and the keypad will feel secure in your hands as your observe. The KEYPRO also offers protection during transport and storage.

Installation:

Caution: The KEYPRO fits closely around the keypad controller. You must work it gently into place. If you force the rubber casing while it is being installed on your keypad, you may tear the rubber.

1. Insert the connector and thread the cable through the opening at the bottom of the KEYPRO. Do not insert the cable and the bottom of the keypad all the way at this time.
2. The first part of the keypad inserted is the top portion with the display.
3. Gently work the bottom portion including the cable connection into place.

USING THE KEYPAD

Getting Started - do this at home, if possible

Set Up your Mount and Cable Connections

Refer to the instructions in the mount assembly manual to set up your mount. The following cables must be connected: RA and Dec cables, and keypad controller cable and power cable, preferably in that order. You do not need the mounting plate or telescope tube assembly for these setup procedures.

Gather Basic Information

You will need to enter your local parameters to ensure that the mount functions properly. The mount needs to know the local time (and if you are on daylight savings) and the longitude and latitude of your observing site. In fact, you can enter up to three observing sites to be stored in memory.

To determine your longitude and latitude, consult your atlas, topographical or automobile maps. You may need to interpolate between the major longitude and latitude lines on the map. The closer you can get the better, however, it is not necessary to be exact to the seconds (last two number entry fields) since the purpose of these entries is to calculate which objects are above your local horizon.

The time zone is determined from the Greenwich meridian. An excellent reference is the Standard Time Zones chart in Norton's 2000.0 Star Atlas. For your reference, these are the US time zones.

US Eastern standard time	05
US Central standard time	06
US Mountain standard time	07
US Pacific standard time	08
US Hawaii standard time	10

Most of this information will be entered only once and will be remembered by the keypad controller. We recommend that you make these entries at home before you go to your observing session to ensure that you have the information that you need. If you have a GPS (Global Positioning System) device, you may want to enter the coordinates once you reach your site and have the proper numbers.

```
Astro-Physics  v2.6
1=Startup  4=S:1200
2=Setup    5=B:64
3=Time     6=T:Side
```
Display 1

Set Site Location (s)

1. **Plug the keypad controller into the GTO Control Panel**. The Astro-Physics Menu will appear.
2. **Choose Setup on the Astro-Physics Menu, then press the NEXT> button twice to go to the Setup-3 Menu**.
3. **Choose Set Site Loc**. The Site Menu will appear.
4. **Select Location-1 (or you could choose location 2 or 3).** The first time the screen appears, zeros or random numbers will be displayed in all number fields.

```
   Setup-3 Menu  <
1=Set Site Loc.
2=Set Date & Time
6/0=Dim/Br. Disp. >
```
Display 2

```
     Site Menu
1=Location-1
2=Location-2
3=Location-3  0=A/P
```
Display 3

```
Long: W 000:00:00
Lat : N  00:00:00
Time Zone     : 00
Daylight Savings: 0
```
Display 4

   a) **Enter your longitude in the first line**. If the "W" is correct (locations west of the Greenwich meridian), use the next button to move the cursor. To change the "W" sign, press the "E" button on the keypad. Note, there no longitudes greater than 180.

   b) **Enter your latitude**. "N" for the Northern Hemisphere and "S" for the Southern Hemisphere.

   c) **Enter your time zone**. The positive or negative value will be calculated based on "W" or "E" in your longitude setting.

   d) **Enter Day-Savings.** Press the "0" number button if daylight savings is not in effect (e.g. winter). Enter "1" if daylight savings is in effect (e.g. summer). After you enter all numbers (you can use the NEXT> button to skip ahead), the controller will save your entry and bring you back to the Setup-3 Menu. Remember to change this when we "spring forward" or "fall back".

   e) **Correct mistakes**. If you have made a mistake in the entry, you must repeat the above sequence. Push the MENU button to return to the Setup-3 Menu and return to the Set Site Loc. Menu.

   f) **Enter other locations**. If you know the coordinates of the sites you want to enter in Locations 2 and 3, enter them now. The controller will save this information.

g) **Changing entries**. If you wish to change any of your entries, follow the above procedure and change any numbers for the new locations.

Note: 0=A/P appears in the lower corner of the display screen. This is a hard-coded selection of the coordinates for Astro-Physics. We use this during the initial testing of your controller.

Set Date & Time

1. **Select Set Date & Time from the Setup-3 Menu**.

   a) Set your local time and date. Use the 24 hour format (e.g. 2:00 p.m. = 14:00). Press NEXT> to skip over correct numbers, enter different numbers as needed.

   b) After entering all numbers, the controller will save your entry and return to Setup-3 Menu.

```
TIME: 22:12:38
DATE: 06/22/1998
```

Display 5

2. **If you are not planning to use the mount at this point**, then simply remove the power cable.

Practice Using your Keypad

You may want to try out your keypad controller while the mount is set up at home. We suggest that you don't put the mounting plate or telescope on the mount since you cannot actually calibrate on a real star. If you guess the location of your calibration stars incorrectly, you may cause the telescope to hit the pier or plate strike the mount. Read the following instructions as you use your keypad to simulate an observing session.

Setting up in the field

Assemble Your Mount

Refer to the instruction manual for your mount to set up at your observing site. Aim the polar axis toward Polaris (or the southern celestial pole) as closely as you can by sighting up the hole in the center of the polar axis or along the axis. Be sure that you connect your RA and Dec cables, keypad controller cable and power cable, preferably in that order. All other connections are optional.

Plug in the keypad

When you plug in the cable of your keypad controller and the power cable, the Astro-Physics Menu will appear with your version number displayed as shown in Display 1. You can make adjustments to basic functions of the keypad at this point:

Brightness of the display screen:

Use the <PREV and NEXT> buttons to adjust the brightness to a bright or dim setting.

Slew rate:

Press "4" on your keypad to change slew rate: 1200x, 900x, or 600x. Note that the selection changes (toggles) each time you press the button.

Button rate:

Press "5" on your keypad to change the button rate: 64x, 600x, 1200, .25x, .5x, 1x, or 12x. This determines the rate that the mount will move when the N-S-E-W directional buttons are pushed. The selection changes each time you press the button.

Tracking rate:

Press "6" on your keypad to change the tracking rate: Side (Sidereal), Sol (Solar), Lun (Lunar)

Directional buttons:

The N-S-E-W buttons are active at this point.

Note:

If you just want to make quick casual visual observations with your telescope and do not plan to use the go-to features of the keypad controller, you can operate your telescope totally from this screen. Since you have set up your mount with the polar axis pointing toward Polaris (or the southern celestial pole) the RA tracking rate will help to keep your object in the field of view. You will, of course, have to move your telescope by hand from one object to another or use the directional buttons. If you have encoders installed (optional accessory), you can use JMI Digital Setting Circles (optional accessory).

Startup Sequence

This startup sequence will allow you to choose your location and go through your polar alignment/calibration routine easily. To follow this routine, you must begin at the Astro-Physics Menu when you first power up. When you leave this screen you cannot access it again unless you remove the power plug and plug it in again.

If you want to change your location or calibrate again later in your observing session, you can do it through the setup menus.

Select Your Location

1. **Plug in the keypad controller, then the power cord.** The Astro-Physics Menu will appear. Refer to Display 1.
2. **Choose Startup**. The mount now requires your location entry from the Site Menu. See Display 3. (You must set up your location before you try this procedure. Refer to "USING THE KEYPAD
3. Getting Started - do this at home, if possible).
4. **Choose Location-1, 2 or 3** (depending on where you are observing). The Cal. Menu will appear. Proceed to the next section on "Calibration and Polar Alignment".

Calibration and Polar Alignment

The mount now needs to be calibrated to a known star (or the sun in the daytime). You will accomplish two goals with this procedure - polar aligning your mount and calibrating on a known star (or stars). The mount uses this information to determine where your telescope is pointing at all times. The encoders of the motors calculate the movement from one position to another and use that information to determine if an object is above the horizon and what movements of the RA and Dec axes are necessary to slew to the object. All movement of your telescope, after you complete your calibration routine, must be done with the keypad hand controller (or computer software program). If you accidentally bump or move your telescope by hand, you will lose your calibration and the mount will no longer know where it is (refer to "What if I lose my calibration ?" to re-calibrate).

You can chose to do a normal Northern Hemisphere polar alignment routine or, if Polaris is not visible, you can chose the 2-star alignment method. Observers in the Southern Hemisphere will use the 2 star alignment. In addition, we have provided a GTO quick star-drift method of polar alignment for the most critical applications.

You need to be roughly polar aligned for all procedures. The closer you are to polar alignment when you start, the faster this procedure will be. Please refer to instructions for setting up your mount in the appropriate manual.

CALIBRATING IN THE DAYTIME
Before calibrating on the sun, you MUST install a safe, quality solar filter. Do not use eyepiece solar filters as they may break in the intense heat of the sun. When you are slewing to any object in the daytime, the telescope may slew across or very near the sun. DO NOT look into the eyepiece as the telescope slews. DO NOT attempt to view any object, e.g. Venus, when it is near the sun. Permanent damage to your eye may result if you look directly at the sun with your telescope. Refer to the section on "SLEWING DURING THE DAY" for further information and warnings.

N Polar Calibrate - Calibrating with Polaris

This routine uses a known star in the eastern or western sky and Polaris to align the mount. The accuracy of your alignment will depend on how orthogonal the telescope is to the mount axes (refer to the "ORTHOGONALITY" section.).

Try to pick a star that has a sufficiently different (+or - four hours) right ascension from Polaris, otherwise this method may not converge on the pole in a reasonable number of iterations. For instance, the star Arcturus is close in right ascension to Polaris and so would not be a good candidate.

```
Cal. Menu
1=N Polar Calibrate
2=2 star Calibrate
3=Resume from Park
```
Display 6

1. **Check position of mount**. Be sure that the polar axis is pointed as close as possible toward Polaris (the North Star). If not, make these adjustments now. Follow the procedures to select your location in the previous section.
2. **At the Cal. Menu, choose N Polar Calibrate**. The Choose Star display will appear. In the upper right of the screen, you will find the zenith hour displayed (e.g. Z=17:17). Zenith hour is synonymous with LST (local sidereal time). This allows you to open your star atlas to the page corresponding to the sky overhead to aid in your calibration star selection.
3. **Move telescope manually (grasp the telescope by hand and move it) to a known bright star which will be your calibration star (Vega in this example) and center it in the eyepiece field with the N-S-E-W directional buttons**. We recommend that you use a crosshair eyepiece.

```
Choose Star Z=17:17
1=Polaris          <
2=Acamar
3=Achernar         >
```
Display 7

4. **Select that star on keypad**. Use the <PREV and NEXT> buttons to scroll through the star list to find the star you have chosen. Select this star by pressing the corresponding number. The RA and Dec values of the star will be displayed. Please note that the LST (local sidereal time) values for your screen will be different than shown here. If you have made a mistake, use the <PREV button to choose another star. There are 300 calibration stars from which to choose.

```
Cal Star:Vega      <
RA :18:36:53
DEC:+38:46:49 Press
LST:17:17:21   GOTO
```
Display 8

5. **Press the GOTO button**. The scope will automatically slew to Polaris which should appear somewhere in the field of a low to medium power eyepiece. This will depend on how close your "rough" polar alignment is.

6. **Center Polaris with the altitude and azimuth adjusters of your mount**. Please refer back to the mount instructions. Do not use the N-S-E-W buttons to center Polaris.

   If Polaris is not in the field at all, you will need to make larger adjustments to the position of your mount. Be sure that the RA axis is pointing as close as possible to the northern celestial pole.

```
Center POLARIS in
Eyepiece with Alt/AZ
GOTO to re-calibrate
Next to Exit Cal.    >
```
Display 9

7. **Exit the calibration routine, or continue for more accurate alignment**. Remember, the more accurate your polar alignment, the more accurate your final pointing accuracy will be.
8. **To continue calibration, press GOTO again**.
9. **Select the same calibration star or choose a different one from the Chose Star display**.
10. **Press GOTO**. The mount will slew to the star you have chosen.
11. **Center the star with the N-S-E-W buttons.**
12. **Press Menu**. The mount will slew to Polaris again.
13. **Make the altitude and azimuth adjustments to center Polaris as before**.
14. **Repeat as needed**. You can repeat this procedure any number of times until you feel that the mount is properly aligned. Each iteration should bring you closer to polar alignment.
15. **Press NEXT>**. Now that you are polar aligned, press the NEXT> button. Note that the "Astro-Physics Menu" has changed to "Main Menu". You are ready to observe.

Quick Routine - Start Sequence using Polaris and Vega

Begin at Astro-Physics Menu. Press in sequence:

1=Startup

1=Location 1 (2 or 3)

1=N.Polar Cal

<PREV or NEXT> button to find Vega

Chose Vega

GOTO button

NEXT> (To exit the calibration routine)

Two Star Calibration

If Polaris is not visible, you will use the 2- star method. The accuracy of your alignment will depend on how orthogonal the telescope is to the mount axes (refer to the "ORTHOGONALITY" section).

1. **Set up your mount so that the RA axis is pointing to the celestial pole as closely as you can.** Follow the procedures to "Select Your Location" as decribed previously.
2. **At the Cal. Menu, choose 2-Star Calibrate**. In the upper right of the Choose Star screen, you will find the zenith hour displayed (e.g. Z=15:43) this allows you to open your star atlas to the page corresponding to the sky overhead.
3. **Decide which star in the eastern sky to use as your 1st calibration star.** There are 200 calibration stars from which you can choose, e.g. Antares.

```
Choose Star Z=15:43
1=Polaris          <
2=Acamar
3=Archernar        <
```
Display 10

```
Cal Star:Antares   <
RA :16:29:24
DEC:-26:25:55  Press
LST:15:45:42   Goto
```
Display 11

4. **Move telescope manually (grasp the telescope by hand and move it) to the star and center it in the eyepiece field with the N-S-E-W directional buttons**. We recommend that you use a crosshair eyepiece.

5. **Select that star on keypad**. Use the <PREV and NEXT> buttons to scroll through the star list to find the star you have chosen. Select this star by pressing the corresponding number. The RA and Dec values of the star will be displayed. Please note that the LST (local sidereal time) values for your screen will be different than shown here. If you have made a mistake, use the <PREV button to choose another star.

```
Cal Star:Regulus   <
RA :10:08:22
DEC:+11:58:01  Press
LST:15:46:00   Goto
```
Display 12

6. **Press GOTO**. This enters the star in the calibration memory. The telescope will not move. The Choose Star screen will come up again.

7. **Choose your second star**, ideally at least 6 hours difference in R.A and preferably 40 degrees or more different in Dec.(e.g. Regulus). Again, the Cal Star screen will appear with the coordinates of your star choice.

8. **Press GOTO**. The mount will slew to this star.The target star should appear somewhere in the field of a low to medium power eyepiece.

9. **Center star with altitude and azimuth adjusters of the mount**. Please refer back to the mount instructions if needed. Do not use the N-S-E-W buttons to center the star. If the star is not in the field at all, you will need to make larger adjustments to the position of your mount.

```
Star: Regulus
RA:   10:08:02
DEC:+11:58:01
Menu to Exit       <
```
Display 13

10. **Press Menu to exit this screen**. The Choose star screen will appear.

11. **You may either end the calibration routine at this point, or continue for more accurate alignment**. Remember, the more accurate your polar alignment, the more accurate your final pointing accuracy will be.

12. **To end the calibration routine, press Menu again**.

13. **To continue calibration, choose the next star that you want to slew to.** You can chose a new star or go back to the first star**. .** Again, at least 6 hours difference in RA and 40 degrees in Dec would be ideal, however you can also pick a star with less difference. You can go back to the original star you chose (e.g. Antares) or some other star that is visible in the sky The display will show the name of the star, RA and Dec coordinates and the LST.

14. **Press GOTO**. The mount will slew to this star.

15. **Center the star in the eyepiece - half of the distance with the altitude and azimuth controls and the other half with the N-S-E-W buttons**.

16. **Press Menu to exit this screen**. The Choose Star list will appear again.

17. **Choose a star**.

18. **Center the star in the eyepiece - half of the distance with the altitude and azimuth controls and the other half with the N-S-E-W buttons**

19. **You can repeat this procedure any number of times until you feel the mount is properly aligned**. Each iteration should bring you closer to perfect polar alignment.

20. Note: Each time you press the Menu button during this procedure, you recalibrate on your current position. Do not press Menu when the mount is slewing or you will cause it to lock up.

GTO Quick Star Drift Method of Polar Alignment.

The star-drift method is the favorite way that astrophotographers align their mounts. After all, they would like the least amount of drift possible during their long time exposures. A go-to mount makes it possible to simulate this method without spending a long time waiting for drift to show up. It is also easy because it separates the two adjustments of altitude and azimuth. Use a crosshair eyepiece for this procedure.

1. **Follow one of the above procedures (one complete cycle) to get close.** You will be at the Main Menu when you finish.

2. **Decide on two stars that straddle the meridian near the celestial equator** (just like the orthogonality described later.). **From Objects Menu, select Tours**.

3. **Choose Stars/Constell and select star**. Scroll through the constellation and star choices to find your first star. If the stars you want to use are listed in the common star names list, you can choose Strs from the Objects Menu and select stars from that list.

4. **Press GOTO**. The scope will slew to your first star on one side of the meridian.

5. **Center the star on the crosshair using the N-S-E-W buttons**. The crosshairs should be aligned in a N-S and E-W orientation for this to work easily.

6. **Go to Objects Menu and choose Rcal**.

7. **Make altitude adjustments**:

a) **Slew to a star directly across the meridian somewhere near the first star**. The star should appear near the center of a low or medium power eyepiece.

b) **Make adjustments**. If the polar alignment is off, the 2nd star will appear north or south of the center of the crosshairs. Ignore any east or west displacement. Use the mount's altitude adjuster to bring the star halfway toward the center of the reticle in the N-S direction. Center the star the rest of the way using the buttons.

c) **Press the Rcal button again (in the Objects Menu).**

d) **Slew back to the first star and adjust the altitude adjuster again as needed**. Do this iteration several times until the 2 stars appear in the center on the N-S axis. It is not necessary to do this at high power, nor is it necessary to get the 2 stars to fall exactly on the crosshairs. If the stars consistently fall within a few arc minutes of the center, this adjustment to the altitude axis is essentially done.

8. **Make azimuth adjustments**:

a) **Pick two stars that are lined up in the east (or west) at similar right ascension values, but are separated by a large declination value**. In the winter, a good combination would be Beta Auriga and Alpha Orionis (Betelgeuse). In the summer, you can use Eta Ursa Majoris (the end star in the handle of the Big Dipper) and Alpha Virginis (Spica).

b) **Slew between these stars**. Again, using the GOTO, slew the scope back and forth between these two stars and adjust the azimuth axis of the mount to center each star in turn on the crosshair in the E-W direction (ignore any small N-S displacement). Remember to use the azimuth adjuster to correct half of the error and the E-W buttons to center the star.

9. When these two adjustments are finished, you will be very accurately polar aligned. The accuracy of this procedure as well as the N-Polar and 2-Star methods depend on how well your telescope holds its orthogonality, Any mirror shifting or diagonal misalignment (that holds for refractor diagonals as well) will not only compromise the polar alignment, but also the ability to accurately center objects when slewing from one to another.

ORTHOGONALITY - If you are having difficulty achieving accurate polar alignment with the above procedures, refer to the section entitled "ORTHOGONALITY".

Observing - have some fun!

Tips for Using the Buttons and Menus

- **Correcting data entries** - When entering catalog numbers into the keypad controller, you can use <PREV button to delete last digit entered. Enter correct digit.
- **Scrolling object lists** - Some of the object selection screens will display "<" and/or ">", usually in the corners. These symbols indicate that you can scroll a list of objects using the <PREV or NEXT> buttons. If you hold these buttons, the object names will scroll quickly in some screens (e.g. stars).
- **N-S-E-W directional buttons** - The N-S-E-W directional buttons can be used when you are in the Main Menu, Object Menu and when the object data screens are displayed. They are not active when you are in object selection screens.
- **Re-calibration** - You can re-calibrate on current object at any time to fine-tune your calibration. Simply return to the Objects Menu, center the object in your eyepiece with the N-S-E-W directional buttons and choose Rcal (re-calibration) from the menu.
- **RA/Dec coordinates of last slew command** - Go to Object Menu and choose R/D. The RA and Dec coordinates of the object that you just slewed to will display. Also see "Display current object" below.
- **Display current object** - Return to Object Menu and press <PREV button. The object data will display, then press NEXT> to display RA and Dec coordinates.
- **Actual current RA/Dec coordinates** - When you are in Objects Menu, press NEXT>. The RA/Dec coordinates of the exact position of your mount will display. These may be slightly different from above display since the calculations that compensate for atmospheric refraction and precession will change the coordinates slightly. Also, if you move the mount with the N-S-E-W directional buttons or with a software program such as *TheSky,* this display screen will be updated and the display by current object screen will not.
- **Cancel slewing at any time** - Press STOP to cancel a slewing operation. Your telescope will stop immediately. The mount will know where it is, so proceed to the next object using the N-S-E-W buttons or catalog requests described below. Do not move the telescope by hand or you will lose calibration.

Procedures Common to all Slewing Commands

```
Objects Menu
1=M     4=Sol   7=R/D
2=NGC   5=Strs  8=Tour
3=IC    6=More  9=Rcal
```
Display 14

- Begin all slewing requests at the Objects Menu (Main Menu → Objects).
- When you press GOTO, if the object is visible from your location and within your safe zone setting, the mount will slew automatically. If not, the screen will display the message "Object below horizon" or "Outside Safe Zone Slewing canceled...".
- When slewing is complete, data for the object will display, e.g. catalog number or name, magnitude, type of object (galaxy, globular cluster, etc.) and the constellation in which the object is located. Press NEXT> for the RA and Dec coordinates and altitude of the object.
- When you are ready to chose the next object to observe, press MENU once or twice as needed to return to a selection menu.
- Although the procedures for each catalog are outlined below, you will find that it is very easy to navigate. The commands are either intuitive or the screen provides instruction. You will quickly move from one object to another.
- If you move the telescope manually at any time, other than the initial calibration routine, you will lose calibration. See section "What if I lose my calibration ?"
- A word about catalog databases. The RA and Dec coordinates for the objects in these catalogs are based on the year 2000. Nevertheless, you will undoubtedly find differences when comparing the data to other sources even it they are also based on the year 2000. Slight differences are acceptable. We have added precession and atmospheric refraction calculations, so the actual RA and Dec coordinate position to which you will slew will vary slightly from the catalog numbers. Please let us know if you find gross discrepancies.

  The separation data of double stars in the ADS catalog is based on "average" numbers. As you know the apparent separation can vary from year to year. Please consult an ephemeris for the most accurate data.

  Magnitudes are estimates and may vary from one source to another. Also, some stars are variable. Some values are missing from the database and will display zeros in the field.

M, NGC, IC

```
Messier Number:

Press GOTO for Obj
Menu to EXIT
```
Display 15

These are the most common catalogs used in astronomy and include the brightest and most famous objects including galaxies, diffuse (bright) nebulae, planetary nebulae, globular clusters and open clusters. Many faint objects visible only in larger instruments are included also. A few objects are listed in more than one catalog, so there is some overlap. M (Messier) = 110 objects, NGC (New General Catalog) = 7,840 objects, IC (Index Catalog) = 5,386 objects.

1. **Go to Objects Menu**.
2. **Choose M, NGC or IC** - press the number that corresponds to your choice (e.g. M=1).
3. **Enter the catalog number with your keypad**.
4. **Press GOTO to initiate slewing or MENU to return to Objects Menu**.

Common Object Names

```
Common Names:
1=47 Tuc          <
2=Andromeda Galaxy
3=Antennae        >
```
Display 16

This is one of our favorite features. Many of us can't remember the catalog number of an object, however we remember the common name. Use this procedure to view 100 of your favorites.

1. **From Objects Menu, select Tour**.
2. **Select Common Obj. Names**. Use <PREV and NEXT> to scroll through list of names.
3. **Chose object**. The screen will display RA and Dec coordinates and LST (local sidereal time).
4. **Press GOTO to initiate slewing or MENU to return to selection menu**.

Solar System Objects (Sol)

```
Solar Menu
1=Mercury 4=Jupiter
2=Venus   5=Saturn
3=Mars            >
```
Display 17

All planets, the moon and Sun.

WARNING - Observing during the daytime can be dangerous. You must refer to the section entitled "SLEWING DURING THE DAY" for precautions.

1. **From Objects Menu, select Sol (Solar).**

2. **Press the number that corresponds to your choice**. Press NEXT> to go to the next screen for additional choices.

3. **The mount will automatically slew to the object**. The magnitude and constellation data will not display for these objects.

```
     Sol-2 Menu
<
1=Uranus     4=Moon
2=Neptune    5=Sun
3=Pluto
```
Display 18

Common Star Names - Non-scientific

Many of these names are of Arabic origin. Refer to "APPENDIX B – ALPHABETICAL STAR LIST" for the stars that we have included. The appendix also shows the Flamsteed-Bayer names and the approximate magnitude of each star.

1. **From Objects Menu, choose Strs (Stars).**

2. **Select the star you wish to observe** . Scroll the stars list by pressing the <PREV or NEXT> buttons. Hold button down for a more rapid scroll rate. Press the number that corresponds to your choice.

3. **Press GOTO to initiate slewing or <PREV to select another star**.

```
Choose Star Z=09:38
1=Polaris          <
2=Acamar
3=Achernar         <
```
Display 19

Greek Star Names, organized by constellation

1. **From Objects Menu, select Tour**.

2. **Select Stars/Constell**. The display will identify the constellation to which your telescope is pointing and offer choices of stars with Greek names within that constellation. Refer to "APPENDIX A -CONSTELLATION ABBREVIATIONS" for the full names of the constellation and APPENDIX F - THE GREEK ALPHABET to help read your star charts.

   a) Use <PREV and NEXT> buttons to scroll through constellation lists. Choose a constellation that is visible.

   b) Press 6 or 0 to scroll through the list of stars available within the current constellation.

3. **Choose a star**. Screen will display RA and Dec coordinates and LST of chosen star.

4. **Press GOTO to initiate slewing or MENU or <PREV to select another star**.

```
< -  Con: Umi  + >
1=alf      3=del
2=bet      4=eps
6=Prev Stars Next=0
```
Display 20

```
Umi alf              <
RA:02:31:50
DEC:89:15:00    Press
LST:09:42:16    GOTO
```
Display 21

Abell Galaxy Clusters

We have included 2,712 of the Abell Galaxy Clusters.

1. **From Objects Menu, choose More**. This will bring you to Objects Menu-2.

2. **Choose Abell Galaxies**.

3. **Enter Abell Number**. Note that not all Abell Galaxies are in the database. If the number that you have entered is not in the database or is below the horizon, the display will let you know. Press <PREV or MENU to return to Objects Menu-2 and start again.

4. **Press GOTO to initiate slewing or MENU to return to Objects Menu-2**.

```
Abell Number:_

Press GOTO for Obj
Menu to Exit
```
Display 22

ADS Double Stars (Aitken Double Star Catalog)

We have included 215 of the most popular double stars in this catalog. Please refer to APPENDIX E - AITKEN'S DOUBLE STAR (ADS) LIST for the ADS numbers that we have included and the corresponding Greek star name.

1. **From Objects Menu, choose More**. This will bring you to Objects Menu-2.

2. **Choose ADS Double Stars**. The screen will display the name of the constellation to which your telescope is pointed. A list of ADS objects within that constellation is shown.

```
< -  Cons: Sco  + >
1=09909    3=09951
2=09913    4=10074
6=Prev ADS Next=0
```
Display 23

   a) Use <PREV and NEXT> buttons to scroll through constellation lists. Choose a constellation that is visible.

   b) Press 6 or 0 to scroll through the list of stars available within the current constellation.

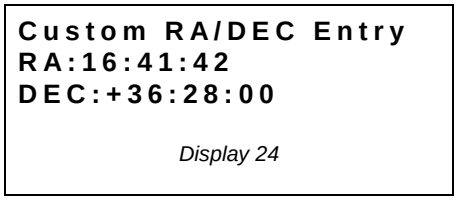
3. **Choose a double star**. When you select an object , the screen will display the RA and Dec coordinates and LST.

4. **Press GOTO to initiate slewing or MENU to make another selection**.

5. **The object data for ADS shows the approximate separation of the double stars**. Remember that apparent separation may vary from year to year. Consult an ephemeris for the most accurate data.

Custom RA and DEC Coordinates

This menu option allows you to slew to any position in the sky as long as you know the RA and Dec coordinates. This feature is particularly handy if you wish to locate comets, super novas, asteroids or any object that is not included in our catalogs.



Display 24

1. **From Objects Menu, select R/D**. The Custom RA/DEC Entry will appear. Your current RA/Dec position will be displayed.

2. **Enter RA and Dec coordinates**. To change "+" or "-" press the "+ -" button. When you finish entering the numbers, the mount will slew to the new position. Object data will display N/A or zeros (the display does not look back to the catalogs to see if any known objects are at the coordinates). Press NEXT> to display RA and Dec coordinates and altitude.

Search for Objects by Type, Magnitude, Catalog and All Sky vs. Current Constellation

Use this routine to specify search parameters, e.g. if you want to view the all the open clusters in the Messier catalog up to 9th magnitude that are visible in the entire sky. This is particularly useful to tailor the list to your aperture or observing preferences.

1. **From Objects Menu, select More**. This will take you to Objects Menu-2.

2. **Select Search Function**. The screen shown in will appear.

Display 25

3. **Use the keypad to make selections to narrow the range of your search**.

   a) **Range** - Press 1 to alternate between these choices: All Sky and Cur. Con. (current constellation).

   b) **Type** - Press 2 to alternate between these choices: All, Galaxy, Open Clus (open cluster), Glob Clus (globular cluster), Planetary (planetary nebula), Nebula, Dbl. Star (double star)

   c) **Mag** (magnitude) - Press 3 to scroll between magnitude levels of 1-20. This will identify the highest magnitude that will be included. Use this to limit your search range to objects that are easily viewed in your telescope.

      The search looks at the whole number of the magnitude so if you specify a limit of 10 in your search, objects between 10-11 will appear also (e.g. 10.6).

      If an object does not have magnitude data available, it is stored as "0". As a result, these objects will appear in your search even if they actually exceed your limit.

   d) **DB** (database or catalog) - Press 4 to alternate between these choices: Mess (Messier), NGC, IC, and Abel (Abell galaxies)

   e) **Press GOTO**. The screen will display "Searching".

Display 26

      i) The display will show the first item of the search and give you several choices as shown.

      ii) If there are no objects that meet this criterion, the Search Menu screen will reappear. Specify new search criterion.

      iii) The search times may be 30 seconds or longer if you are searching a large database, like NGC objects.

   f) **Press GOTO again if you want to slew to this object**. Object data will display. Press NEXT> for more data (RA/Dec coordinates and altitudes).

   g) **Press MENU**. The next search object will display or if there aren't any more, the search menu selection screen will reappear.

   h) **Press MENU again to return to Objects Menu**.

Tour Objects within Constellations

If you are observing within a constellation and want to know what other Messier, NGC, or IC objects are nearby, this tour will provide you with lots of observing ideas.

1. **From Objects Menu, select Tour**.
2. **Select Objects/Constell**. The display will identify the constellation to which your telescope is pointing and offer choices of objects within that constellation.
   a) Use <PREV and NEXT> buttons to scroll through the alphabetical constellation lists. Choose a constellation that is visible.
   b) Press 6 or 0 to scroll through the list of objects available within the current constellation.
3. **Choose an object**. Screen will display the number, RA and Dec coordinates and LST of chosen object.
4. **Press GOTO to initiate slewing or MENU to make another choice**.

```
< -  Cons: And  + >
1=M031  3=NGC7640
2=M032  4=NGC7662
6=Prev Obj Next=0
```
Display 27

Display Time/LST

This display screen will show your local time, date, LST (local sidereal time, also known as the zenith hour) and GMT (Greenwich Mean Time). If you have not gone through the startup routine, only the local time and date will display. It cannot calculate LST and GMT until you enter your location.

From Main Menu or Astro-Physics Menu

1. **Display Astro-Physics Menu** (available only when you first turn the power on) or the Main Menu (after you finish startup routine).
2. **Choose Time/LST.** This is a display screen. You cannot change the data here. Press and hold MENU button a few seconds to exit screen.

```
TIME: 17:40:12
DATE:07:06:1998
GMT:  22:40:29
LST:  11:42
```
Display 28

Declination Backlash Adjustment

When using the 1x, .5x and .25x guide rates in declination, you may find that there is a delay when attempting to reverse the motion of the star. Normally declination drift is only in one direction and will require correction with only one button. However, occasionally it may be necessary to reverse the motion. The multiple gear train inside the drive motors takes a number of pulses to unwind and rewind in the opposite direction. To compensate for this, we have included a circuit that pulses the motor very rapidly for a moment before continuing at the slower rate. Because the delay varies with each motor, we have programmed a 10 position adjustment which can be used to dial in the exact amount of compensation.

1. **At Main Menu, press 5=B.** This controls the speed of your N-S-E-W directional buttons. Continue to press 5 to scroll (toggle) through choices.
2. **Select .25**.
3. **Chose Setup.** Setup -1 Main Menu will appear.
4. **Press 3=DEC Backlash**. As you continue to press 3, the number field will scroll 0-9.
5. **Stop selection on 3 (or any other number you chose)**. We recommend that you start with 3 if you are beginning your adjustment.
6. **While viewing a star at high power through an eyepiece, use the N-S buttons to test this setting at .25x**. You have set the compensation number correctly when the telescope will move almost instantaneously when reversing the direction in declination.
7. **Repeat process, increasing Dec Backlash setting by 1 each time to evaluate changes**.
8. **The number will remain in permanent memory and will not need to be set again**.

```
   Setup-1 Menu  <
1=RA Backlash :0
2=Focus       :Low
3=DEC Backlash:0  >
```
Display 29

R.A. Backlash Adjustment

Since the R.A. motor is always running, there is no backlash or delay in the R.A. motion in 0.25x, 0.5x, and 1x. Where R.A. backlash becomes noticeable is in the 12x, 64x and higher slew rates. Here, backlash will manifest itself as a delay in the continuation of the R.A. drive. In other words, the star will continue to drift for a number of seconds after letting go of one of the two directional buttons (E or W). This is the time it takes for the motor gear train to completely reverse again to begin the normal tracking. There is no drift in the other direction because you are not unwinding the gear train. Adjustment of the backlash is very simple.

1. **At Main Menu, press 5=B.** This controls the speed of your N-S-E-W directional buttons. Continue to press 5 to scroll (toggle) through choices.
2. **Select 12x or any higher speed.** We recommend 12x since this is the easiest to evaluate.
3. **Chose Setup.** Setup -1 Main Menu will appear.
4. **Press 1=RA Backlash**. As you continue to press 1, the number field will scroll 0-9. Zero will have no compensation and 9 will probably be overcompensated.
5. **Stop selection on 3 (or any other number you chose)**. We recommend that you start with 3 if you are beginning your adjustment.
6. **While viewing a star at high power through an eyepiece, use the E-W buttons to test this setting at 12x**. With the proper backlash setting, the star will appear to stop moving right when the button is released. Too high a setting will cause the star to jump back a bit. If this happens select the previous number.
7. **Repeat process, increasing RA Backlash setting by 1 each time to evaluate changes**.
8. **The number will remain in permanent memory and will not need to be set again.**

Focus Adjustment

If you are using an electric focuser such as the ones offered by JMI or Meade, you can control the in and out focus movement with the keypad controller.

1. **Plug the power cord of the focus unit into the GTO Control Panel**.
2. **Hold the focus button with one finger and press the <PREV or NEXT> buttons to change focus.**
3. **To change the speed, go to Setup-1 Menu**. (Main Menu → Setup).
4. **Press 2=Focus**. The rate choice will alternate (toggle) between Low and High.
5. **Select rate**

Note: If you are using the keypad and *TheSky* software together, it is best to use either one or the other to control the focus and not try to use both alternately. Use the keypad if you are standing at the eyepiece, use *TheSky* if you are focusing a CCD image from your computer screen.

Both the keypad and *TheSky* default to the slow speed when you begin your session. However If you change the keypad to the fast setting, then use *TheSky,* you will notice that *TheSky* focus speed will be fast even though “slow” has been selected from the dialog box. To gain control with *TheSky*, simply select “fast”, then “slow.” The speed will now operate at slow. The same is true if you focus with *TheSky* first, then switch to the keypad. Use the same technique to gain control with the keypad. This occurs because the Servo Drive Box stores the last focus speed information and until you actively change the speed with either device, it will remember the speed last used.

Calibrate Menu

Calibration must be done from the startup sequence when you first plug in your keypad and power cord as described in the section “Calibration”. You can also access a calibration menu from the Setup Menu as follows if you accidentally move the telescope and must recalibrate. You can not use this for the initial calibration, because there is no way to select your location in this menu.

```
   Setup-2 Menu    <
1=Calibrate Menu
2=Photo Timer
3/4=Reticle: 2      >
```
Display 30

1. **Go to Setup-2 Menu**. (Main Menu → Setup → press NEXT> twice).
2. **Choose Calibrate Menu**. You have several choices.
   a) N Polar Calibrate - Refer to the section “N Polar Calibrate - Calibrating with Polaris”.
   b) 2-Star Calibrate - Refer to the section “Two Star Calibration.
   c) Resume from Park - Refer to the section “Parking Your Telescope”.

What if I lose my calibration ?

1. Go to calibrate Menu as described above and follow the N Polar Calibrate or 2-Star Calibrate procedure. Since you will already be polar aligned and your location has been selected, you are simply telling the mount where it is pointing. No further adjustments should be needed.

Photographic Timer

Activate the countdown photographic timer to remind you when your exposure is completed. An audible beep will alert you that the time has expired.

1. **Go to Setup-2 Menu**. (Main Menu → Setup → press NEXT> twice).
2. **Choose Photo Timer.** The Photographic Timer screen will appear.
3. **Enter hours, minutes and seconds**. The timer will activate.
4. **When the timer reaches 0, a series of audible beeps will sound.** The display will begin to show negative numbers to let you know the time that has elapsed since the timer went off.
5. **Press MENU to cancel timer at any time.**

Display 31

Reticle Illuminator Adjustment

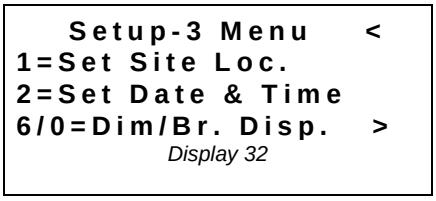
The brightness of an illuminated reticle can be adjusted with the keypad. Plug the cord of the reticle into the connector on the GTO Control Panel.

1. **Go to the Setup-2 Menu**. (Main Menu → Setup→press NEXT>once).
2. **Press the 3 and 4 buttons to desired brightness level from 0-9**. Button 4 will increase, 3 will decrease. If you press 3 repeatedly, it will toggle between 0 and 1.

Set Site Location

Refer to the earlier “USING THE KEYPAD

Getting Started - do this at home, if possible” for this information.



Display 32

Set Date & Time

Refer to the earlier “USING THE KEYPAD

Getting Started - do this at home, if possible” for this information.

Adjust Brightness of Screen Display

There are two adjustment levels - bright and dim. If you observe during the day, set to the bright level and shade the screen with your hand. These are the two locations that you can adjust brightness:

From Main Menu

You can adjust the brightness of the screen display by pressing the <PREV or NEXT> buttons while you are in the Main Menu.

From Setup-3 Menu

1. **Go to Setup-3 Menu**. (Main Menu → choose setup → press NEXT> twice).
2. **Press 6 to dim screen and 0 to increase screen brightness**.

Permanent Error Memory Adjustment

Astrophotography and CCD Imaging demand the highest tracking accuracy to obtain pinpoint star images throughout your photographic exposure.

The servo drive electronics contain a very sophisticated periodic error compensation circuit. Because a majority of the periodic error is due to the RA drive worm and is quite predictable, it is possible to significantly reduce it by simply having the controller “memorize” the corrections you make with your button inputs and automatically play them back for each cycle of the worm. This circuit has some unique features that makes it easy to operate and almost totally foolproof.

Use the start sequence described in “Calibration and Polar Alignment” to polar align so that you have minimum R.A. and Dec drift. Be sure that the night is steady enough with minimum atmospheric motion, and pick a star near the zenith to minimize atmospheric refraction errors. You must use an eyepiece with a crosshair. The recording process will take about 7 minutes to complete for the 1200 and 900 mounts and 8 minutes for the 600E and 400 mounts.

Record Permanent Error Memory

```
   Setup-4 PEM    <
PEM State: None
1=Record   2=Play
3=Set PEM to None <
```
Display 33

1. **Select response rate for N-S-E-W buttons at the Main Menu**. For medium power, use 1x, for higher powers use .5x or .25x.
2. **Go to Setup-4 PEM Menu**. (Main Menu → Setup → press NEXT button 3 times → Setup-4 PEM menu).
3. **Be sure the PEM state is set to NONE.**
4. **Put star on crosshair**. Place a medium brightness star on the crosshair at moderately high power so you can easily see the R.A. gear drift. Practicing moving the star with your N-S-E-W directional buttons to get the feel of guiding.
5. **Choose Record**. The record cycle will begin approximately 10 seconds later, signaled with a single audible beep. The screen will show "Recording" throughout the entire cycle.
6. **Keep star on crosshair.** During the 7 (or 8) minute recording period, it is necessary to keep the star on the crosshair using the N-S-E-W directional buttons. Every button input will be recorded. Avoid trying to guide out any atmospheric scintillation since this will add a random noise error into your final guide rate. If an ST-4 autoguider is available, it can be used to guide, and the controller will faithfully remember each error correction that it makes. An autoguider is extremely accurate and will place into memory a very smooth correction of the gear error. A countdown timer is provided for your convenience. You cannot cancel the recording session.
7. **Screen will return to Setup-4 Menu and you will hear a beep when the recording cycle is complete.**
8. **Press Play to activate the corrections**. You can watch the crosshair again to see how accurately your corrections were made. If you are not satisfied with your results, record again using the same procedure.

Playback PEM corrections

Activate the corrections when guiding astrophotos or CCD images.

1. **Choose Play from the Setup-4 PEM menu**. The controller will automatically play back the correct portion of the worm gear error at whatever tracking, slewing or directional button rate that you choose.

Special Features

A most valuable feature of this circuit is that it automatically compensates for any drift inadvertently introduced by the operator in the process of recording the gear error. For instance, if the mount was not properly polar aligned in altitude, the right ascension drift rate would be in error. The circuitry automatically subtracts this slow drift from the memory, so that the overall long term drive rate remains exactly at the sidereal rate, This way, the compensated driving rate will always be correct for any other position in the sky and for any other time that the mount is set up in the field. When the mount is properly aligned, it is possible to take 15 to 30 minute unguided astrophotos without trailed star images. For more critical exposures, the controller memory allows the astrophotographer to check the guidestar only occasionally during a long exposure.

Specify Mount Type

This setting is made at Astro-Physics. To check or make corrections, follow this procedure.

```
    Mount Menu    <
1,2,3=Park    4=Load
5=Safe Zone :00
6=Mount Type:AP1200
```
Display 34

1. **Go to Mount Menu**. (Main Menu → Setup → NEXT 4 times → Mount Menu).
2. **Press 6=Mount Type**. Notice that the number field changes each time you press 1.
3. **Scroll through choices** - Continue to press 1 to choose: Astro-Physics1200, AP900, AP600E, AP400.

Set Safety Zone Limits for Your Telescope

Astro-Physics mounts are used with a wide variety of telescopes, piers, tripods and accessories. You may determine that if the telescope attempts to point to some areas of the sky, it may hit the pier or tripod.

How to Determine Your Safe Zone

Determine by trial and error how close in degrees you can safely slew your scope. This may vary depending on what accessories are on your scope (e.g. CCD camera with filter wheel vs. an eyepiece).

Set Your Safe Zone

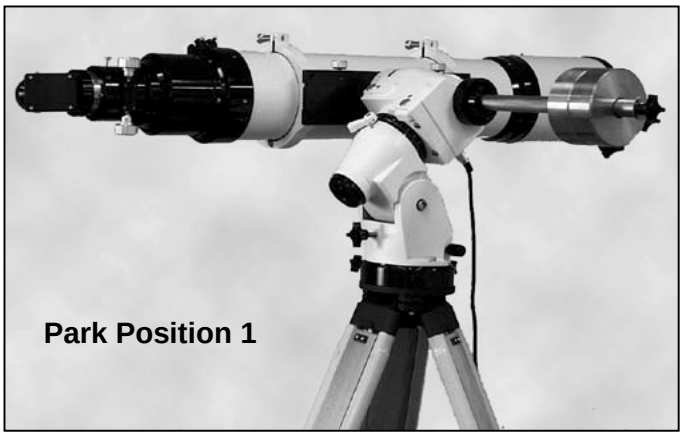
1. **Go to Mount Menu**. (Main Menu → Setup → NEXT 4 times → Mount Menu).
2. **Press 5=Safe Zone**. Notice that the number field changes.
3. **Enter number of degrees**. As you continue to press 2, the number choices increase from 0-20 and back to zero.

Load

This feature allows software updates of the keypad controller when upgrades are available in the future. We will provide instructions at that time.

Parking Your Telescope

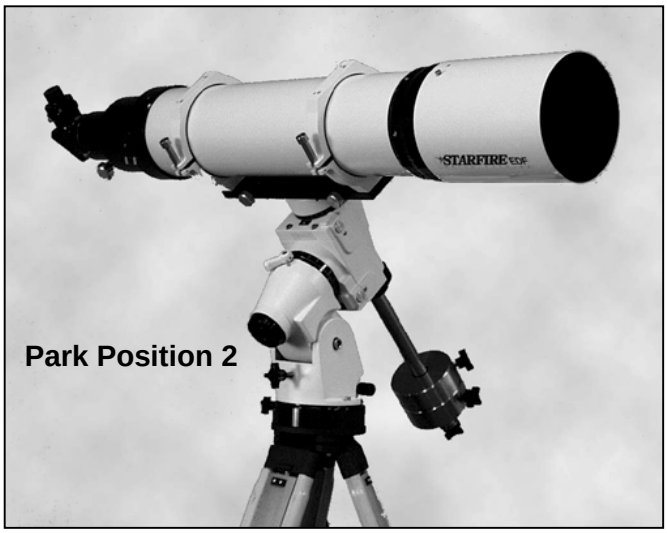
The hand controller allows you to park the telescope at the end of your observing session. You can then turn off the power and the mount will retain this position for the next session. When the park command is cancelled, you are ready to resume without going through the calibration routine. Once the telescope is parked it cannot be moved by hand or the calibration will be lost and you will have to repeat the startup sequence at the beginning of your next observing session.



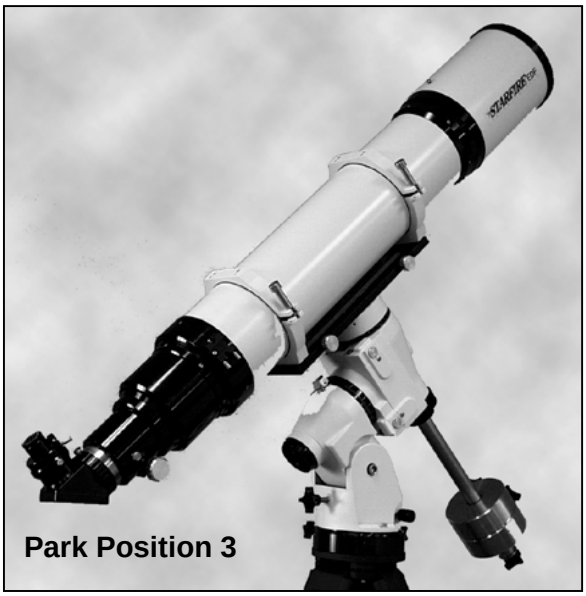
Scope is level and pointing north. This position is also as the Reference Park Position.
RA horizontal, Dec = 90 Latitude

Consideration

The mount is powered by 12V DC, however you can use a 110 to 12V DC power supply (3 amp minimum) whenever 110V is available. We recommend that you do not leave your mount *known* plugged into 110V current when you are not observing. It is better to remove the power plug so that if your observatory is struck by lightening or a severe power surge occurs, your drive electronics will not be damaged. We recommend that you take the same precautions with your drive electronics that you would take with any fine electronic equipment.



Scope is level and pointing east.
RA axis vertical, Dec = 0



Scope is pointing to the pole.
RA axis vertical, Dec = 90

Park routine

1. **Go to Mount Menu**. (Main Menu → Setup → NEXT 4 times → Mount Menu).
2. **Choose either 1,2 or 3 with the buttons**. Depending on which number you choose, the scope will slew to one of the park positions shown in the photos. The screen will state "Please wait till scope reaches park point. Press MENU to Park."
3. **Press MENU.** The park procedure is now complete and the position has been written into the keypad memory. The screen will display "Park 1 Activated. Press Menu to Resume."
4. **Remove the power to avoid damage by lightening.** Disconnect the power supply from the wall for optimal protection.
5. **Turn on the power when you are ready to begin your next observing session.**. The Astro-Physics Menu will appear.
6. **Choose Startup**.
7. **Select your location**. The Cal. Menu will appear.

- **Select Resume from Park**. This will bypass the calibration routine. The Main Menu will display and you are ready to observe.

Reference Park

Park 1 is also known as the "Reference Park" position because this position can be accurately re-created using an ordinary carpenter's bubble level. This is handy in these circumstances:

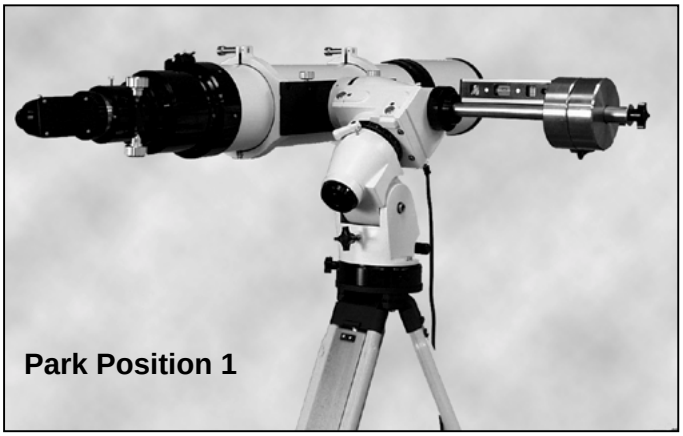
- The scope was left in the Park 1 position, but the mount was accidentally bumped or moved. One could theoretically remove the tube assembly from a permanently mounted equatorial and leave the axes in any position. Then, when it's time to observe again, the tube assembly is attached, and the two axes are leveled with an ordinary carpenter's level. "Resume from park" can then be used just as if the scope was never disturbed.

- Park 1 is the default position even if the scope has never been parked before. If the mount is already polar aligned, but you forgot to park if before turning the power off, you can level the two axes with a carpenter's level as in the previous example and select "Resume from Park" from the Cal. Menu.

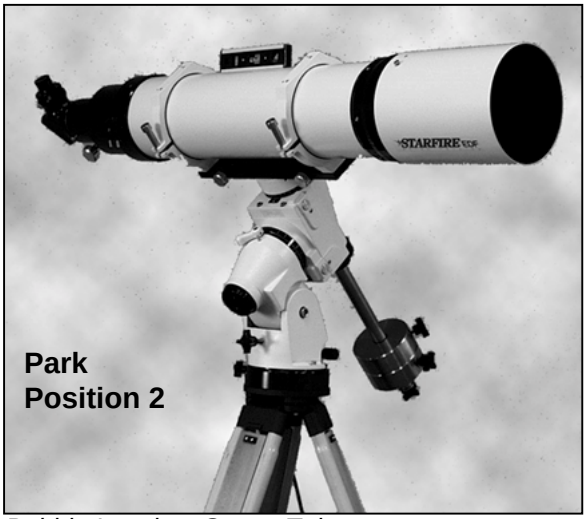
- The last park position you chose will remain in the controller memory. If you forget to park the mount properly with the keypad, but the last park position that you used was Park 1, then you can use the bubble level as in the previous two examples.

Using the Reference Park position to accurately polar align your telescope in the daytime or when Polaris is not visible.

1. **Manually move mount to Park 1 position.**
   - a) Point the mount roughly north and approximately level both axes Refer to the photo.
   - b) Place a carpenter's level on the counterweight shaft and move the RA axis manually until the shaft is precisely level. This will place your mount in the Park 1 position.
   - c) Tighten the R.A. axis clutches so that the axis cannot be moved accidentally.
2. **Turn on the power to the mount and go through the startup sequence** (Startup → Location → Resume from Park).
3. **Set Park 2 position**.
   - a) Enter Setup and scroll to the last menu (Mount Menu).
   - b) Press Park 2. Wait until the scope has slewed to the Park 2 position.
   - c) Press MENU. The keypad will display "Park 2 Activated".
   - d) Using the bubble level, level the tube manually by turning the Dec axis only. Do not move the R.A. axis.
   - e) Tighten the Dec clutches so that it cannot be accidentally moved.
   - f) Press MENU to resume from park.



Bubble Level on Counterweight Shaft



Bubble Level on Scope Tube

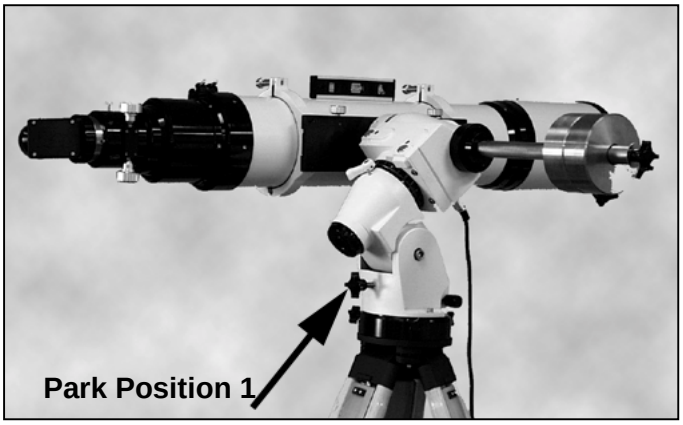
4. **Set Park 1 position and make altitude adjustments**.

   a) Press Park 1. Wait until the scope slews to the Park 1 position.

   b) Press MENU to set the park position. Park 1 will be activated.

   c) With the carpenter's level, level the scope tube using the mount's altitude adjuster. Do not move the axes by hand.

   d) Press MENU to resume from park.



Use altitude adjuster to level tube.

5. **Slew to object and make azimuth adjustments if needed**.

   a) Scroll back to the Main Menu.

   b) Enter Objects Menu and choose the object that you want to slew to. The mount will now slew to where the object is, assuming that the azimuth adjustment is correct (the mount is pointed exactly true north). These are some possible object choices.

      i) Sun - The sun is the most visible choice, of course, but you must exercise extreme caution when using this target. You must use a proper solar filter if you wish to image the sun in your eyepiece. Failure to do so may damage your optics and your eyes! If you don't have a filter, you can do this step with the dustcover on your scope (and finderscope) by observing the shadow of the tube on the ground. Another way is to line up the shadow of the front mounting ring on the rear ring. This is easy to do with Astro-Physics rings because the two corners on the top of the ring cast a sharp shadow.

      ii) Bright star or planet - You may also choose a bright star or planet if the sun has already set.

      iii) Moon

   c) Make azimuth adjustments if needed. If the scope is pointed left or right of the object, simply turn the azimuth adjusters until the object is in the field.

The accuracy of this method depends on how accurate your controller's clock and your location has been set. Tests done with an ordinary 7" carpenter's level shows that the mount can be adjusted level to accuracy within 15 arc minutes. We used a Mayes brand "SUPER-CEDE" model that was purchased at a local hardware store. This level has a groove for accurate alignment on curved surfaces. It works well on both the counterweight shaft and the telescope tube.

ORTHOGONALITY

It is important that the telescope optical system be orthogonal to the mount axes. A telescope is not orthogonal if the optics are pointing to an angle other than exactly 90° to the Dec. Axis. Otherwise, precise polar alignment is impossible and the pointing accuracy will be reduced by exactly twice the orthogonal error.

While our mount axes are very accurately machined and are very close to orthogonal (i.e. the Dec axis is precisely 90% to the RA axis), the telescope optical axis can be significantly misaligned to the two mount axes. This could be due to improperly machined rings, wedge in the cradle plate, diagonal displacement or tilt in a Newtonian (or even incorrect position of the mirror in diagonal for refractors), mirror shift in a catadioptric, etc. Whatever the reason, orthogonalilty can be easily checked and adjusted if needed.

To do an orthogonal check, the mount should be close to polar aligned, but doesn't have to be perfect. All you need to do is slew between two stars that are straddling either side of the meridian.

For instance, in early summer at 9 p.m. (northern hemisphere), the constellation Boötes is straight up and Alpha Boötes (Arcturus) and Epsilon Boötes are on either side of the meridian. Follow this procedure using a crosshair eyepiece:

1. **From Objects Menu, select Tours**.
2. **Choose Stars/Constell and scroll to "Cons:Boo".** (If the stars you want to use are listed in the common star names list, you can choose Strs from the Objects Menu and select the stars from that list).
3. **Choose "alf".** The RA and Dec coordinates and LST will display
4. **Press GOTO**. The scope will now slew to Arcturus in the west.
5. **Center the star on crosshair using your N-S-E-W buttons**.
6. **Return to Objects Menu**. (Press the MENU button twice.)
7. **Press RCal**. This will recalibrate your scope precisely on Arcturus.

8. **Return to Tours**. In this example, the constellation Boötes will display since you are now pointed to it.

9. **Choose "eps".**

10. **Press GOTO**. The scope will now slew all the way around the dec axis to point east to Epsilon Boötes. If the polar alignment was not exact, the new star will appear displaced north or south in declination. Ignore that error for the moment (you can bring the star back in Dec with the buttons, but NOT R.A). The amount that the star is displaced in R.A. will be equal to twice the optical tube assembly orthogonal error.

11. **Correct orthogonality**. Simply shim up one of the tube rings to bring the star *half way* toward the crosshair.

12. **Center the star with the N-S-E-W buttons**.

13. **Return to Objects Menu**. (Press the MENU button twice.)

14. **Press RCal**.

15. **Slew back to the first star**. Add additional shims as necessary (or adjust your optics if that is the problem) until both stars appear on the centerline of the crosshairs.

SLEWING DURING THE DAY

Your must take extra precautions when observing during the daytime. ***If not done correctly, you may suffer permanent damage to your eyesight*.** Be sure to supervise all children and other observers who may not be aware of the dangers.

Observing in the daytime offers many rewards - finding the planets and stars, and observing sunspots and solar prominences of the sun itself.

Potential Dangers

- As the telescope is slewing from one part of the sky to another, it may pass across the face of the sun or near enough so that looking through the telescope would be dangerous unless you have a proper solar filter. DO NOT LOOK DIRECTLY INTO THE TELESCOPE OR VIEWFINDER WHILE THE TELESCOPE IS SLEWING.
- The position of the planet or star that you wish to see may be too close to the sun to observe safely. CHECK THE POSITION OF THE TELESCOPE BEFORE YOU LOOK INTO THE EYEPIECE OR VIEWFINDER. BE SURE THAT IT IS NOT POINTING AT OR ANYWHERE NEAR THE SUN. Remember that the finder has a wide field of view so you can see a large portion of the sky.
- Observing the sun. Be sure that you have installed a good quality SAFE filter that covers the optics in front of the telescope. Never use eyepiece filters since they may break due to the intense heat of the sun. Do not use solar filters that are cracked (glass), torn (mylar) or have many pinholes (either glass and mylar).

How to Observe Safely

1. Place dust cover or proper solar filters on the main objective of the telescope and the finder scope before you slew the telescope, use the N-S-E-W directional buttons or move it manually. Be sure to inspect your solar filter beforehand to be sure that it is not damaged in any way to let light through. If you are using a glass solar filter, use black marker to cover the pinholes that may appear in the coating.
2. Slew or move the telescope.
3. Visually check the position of the telescope to be sure that it is not pointing at or anywhere near the sun.
4. If you are observing planets, the moon or stars - remove the dust cover or filter only when you are sure that it is safe.
5. To observe the sun - ALWAYS leave your solar filter in place over the front of the objective and finder.
6. Put the solar filters or dustcovers back on the telescope before slewing to the next object.

TROUBLESHOOTING - additional tips are in the mount instruction manual

The keypad controller locked up when I was calibrating.

This will happen if you press the menu button before the mount has finished slewing. During the calibration function, pressing the menu button recalibrates on your current position. The proper procedure allows the mount to finish slewing, you make the required adjustments, then press menu which will recalibrate and take you to the next step.

If the keypad locks up, simply disconnect your power cable (or flip the switch your power supply if you have one), then reconnect the power and begin the startup procedure again.

The keypad locked up when I try to select my location during the startup sequence. Also, the keypad did not exit the Set Date & Time (Setup Menu #3 entry screen) and locked up.

These two problems indicate that the keypad and servo box are unable to communicate with each other. There are several possible causes:

- The motors are not connected to the servo box. Please check your connections.
- One of the motors is not functioning. Test this by setting the slew rate to 1200x (on the Main Menu) and use the N-S-E-W buttons to move the motors in all directions.
- The mesh of the worm gear and worm wheel is too tight. This will cause the motors to overload which will cause the overload protection feature of the servo box to activate and shut down the signal to the motors. Test this by setting the slew rate to 1200x (on the Main Menu) and use the N-S-E-W buttons to move the motors in all directions.
- The microprocessor chip which contains the program logic is missing from the servo box.

The telescope slewed in the wrong direction toward the pier.

As long as you provide the mount with proper information, your telescope will slew safely from one part of the sky to another. These are a few scenarios that can cause a problem:

- Your time or daylight savings is not set correctly. In the location menu, press the “0” number button if daylight savings is not in effect (e.g. winter). Enter “1” if daylight savings is in effect (e.g. summer). Remember to change this when we “spring forward” or “fall back”.
- When you selected your calibration star, the scope was set up on the wrong side of the mount. Or, in conjunction with the daylight savings issue, if the daylight savings is set incorrectly and you choose a star near the meridian, the scope may be on the wrong side of the mount according to the time set on the keypad.
- If you image through the meridian, finish your exposure, then press Recal before going to another object, your telescope will slew into the mount. Don’t use Recal in this situation, simply go to the next object. Then recalibrate, if you wish.

I pressed the keypad button and it jumped ahead two steps.

This happens if you hold the button too long. Just give it a short press.

USING *THESKY*™ SOFTWARE WITH THE GOTO KEYPAD

These instructions are based on Software Bisque's *TheSky*™ version 4. *TheSky Astronomy Software* is a trademark of Software Bisque. The telescope must be polar aligned to slew accurately. The go-to keypad will guide you through this process.

Hardware Setup

1. **Set up your mount per the mount instruction manual**.
2. **Go through the Startup routine with your keypad per the instructions on page 6 of this manual**. You will be polar aligned and calibrated at the end of his routine.
3. **Plug the computer cable into the GTO Control Panel at the connector marked COM 1 or COM 2** (it doesn't matter which one). Use a computer serial cable with a 9 pin connector on one end (to attach to the servo box of the mount) and a connector that will attach to the serial port of the computer that will be used. Determine which COM port is available on your computer
4. **Plug the other end of the cable into your computer**.

Software Setup

Turn on your computer and open *TheSky* software.

1. **Setup Site Information**. You can skip this if you have already entered this information in a previous session.
   a) **Click DATA in the menu bar.**
   b) **Click SITE INFORMATION**.
   c) **Enter your location and date and time information**.
   d) **Click OK or APPLY and CLOSE**.
2. **Set telescope type**.
   a) **Click TELESCOPE in menu bar**.
   b) **Click SETUP**. The Telescope Setup box will appear.
   c) **Select "LX200 by Meade."** This is the setting that we must use since Software Bisque has not added an Astro-Physics setting yet.
   d) **Click SETTINGS**.
   e) **Choose the COM port that you are using on the computer and set the baud rate to 9600**.
   f) **Click OK, select any other display options that you prefer**. Refer to the manual provided with your software.
   g) **Close the Telescope Setup box.**
3. **Link mount to *TheSky*™**
   a) **Click TELESCOPE again.**
   b) **Click LINK and ESTABLISH**. A message on the screen will confirm that link has been established. A crosshair circle will appear the star map at the point where you slewed most recently with the keypad controller.
4. **Using the keypad and *TheSky* together**. You can switch back and forth between the keypad and *TheSky* as you wish. The mount will supply the RA and Dec coordinates to both continuously so that they always know where they are pointing.
   a) **If you slew with the keypad**.
      - **Keypad displays**- When you have arrived at the object, the object data screen will appear. If you return to the Objects Menu, you can press PREV to see the data on the last object you selected. The NEXT button will show you the current position.
      - ***TheSky* displays** - The crosshair circle will move across the star map on your computer screen as your mount slews. Click on the object to see the Object Information.
   b) **If you slew with *TheSky*.**

- ***TheSky* displays** - The crosshair circle will move across the star map on your computer screen as your mount slews. Click on the object to see the Object Information.
- **Keypad displays** - The current object screen display will not change to show data for the new object. However, if you go the Objects Menu and press the NEXT> button, the correct current position will display.

c) **Focus Adjustment**

If you are using the keypad and *TheSky* software together, it is best to use either one or the other to control the focus and not try to use both alternately. Use the keypad if you are standing at the eyepiece, use *TheSky* if you are focusing a CCD image from your computer screen.

Both the keypad and *TheSky* default to the slow speed when you begin your session. However If you change the keypad to the fast setting, then use *TheSky,* you will notice that *TheSky* focus speed will be fast even though "slow" has been selected from the dialog box. To gain control with *TheSky*, simply select "fast", then "slow." The speed will now operate at slow. The same is true if you focus with *TheSky* first, then switch to the keypad. Use the same technique to gain control with the keypad. This occurs because the Servo Drive Box stores the last focus speed information and until you actively change the speed with either device, it will remember the speed last used.

d) **Reticle Brightness**

The reticle brightness control in *TheSky* is reversed from our default setting of the Servo Drive Box. This should not be important since you will stand at the eyepiece and adjust the brightness with your keypad.

USING *THESKY™* SOFTWARE WITHOUT THE GOTO KEYPAD OR *DIGITALSKY VOICE*

These instructions are based on Software Bisque's *TheSky™* version 4. *TheSky Astronomy Software* is a trademark of Software Bisque. *DigitalSky Voice™* is a trademark of Astro-Physics.

Tracking and Slewing Rates

If you are using *TheSky* without the keypad controller or *DigitalSky Voice* software, the tracking and slewing rates will operate in the default setting of the mount. They cannot be changed with *TheSky* software.

Default tracking rate: sidereal
Default slewing rate: 1200x

Polar Alignment

The telescope must be polar aligned to slew accurately. This is easiest to do if you have a polar alignment scope. If not, you can use *TheSky* software to polar align as described below.

Hardware Setup

1. **Plug the computer cable into the GTO Control Panel at the connector marked COM 1 or COM 2** (it doesn't matter which one). Use a computer serial cable with a 9 pin connector on one end (to attach to the servo box of the mount) and a connector that will attach to the serial port of the computer that will be used. Determine which COM port is available on your computer
2. **Plug the other end of the cable into your computer**.
3. **Plug power cord into GTO Control Panel on the mount.**

Software Setup

Turn on your computer and open *TheSky* software. You must complete every step of these instructions each time you begin the program.

1. **Setup Site Information**. You can skip this if you have already entered this information in a previous session.
   a) **Click DATA in the menu bar.**
   b) **Click SITE INFORMATION**.
   c) **Enter your location and date and time information**.
   d) **Click OK or APPLY and CLOSE**.
2. **Set telescope type**.
   a) **Click TELESCOPE in menu bar**.
   b) **Click SETUP**. The Telescope Setup box will appear.
   c) **Select "LX200 by Meade."** This is the setting that we must use since Software Bisque has not added an Astro-Physics setting yet.
   d) **Click SETTINGS**.
   e) **Choose the COM port that you are using on the computer and set the baud rate to 9600**.
   f) **Click OK, select any other display options that you prefer**. Refer to the manual provided with your software.
   g) **Close the Telescope Setup box.**
3. **Link mount to *TheSky***
   a) **Click TELESCOPE again.**
   b) **Click LINK and ESTABLISH**. A message on the screen will confirm that link has been established. A crosshair circle will appear the star map.
   c) **Click on TELESCOPE again**.

d) **Click OPTIONS and INITIALIZE**. You must go through each step on this "initialize" screen. Follow these directions carefully. You must click each of these buttons to confirm that the information is correct. If the information is not correct, return to the "Setup Site Information" section above and make corrections.

i) **Date**: Look at the date that is displayed. Then click SET DATE. You must click SET DATE to confirm that the information is correct. An error message will display "Error setting date". Click OK. This is an error in *TheSky* software. It is not critical to the operation of the mount, however the horizon limits in *TheSky* may not be correct.

ii) **Time**: Look at the time that is displayed. Make corrections if necessary, then click SET TIME. Click OK in the box that appears.

iii) **Latitude**: Look at the latitude display. Make corrections if necessary, then click SET LATITUDE. Click OK in the box that appears.

iv) **Longitude**: Look at the longitude display. Make corrections if necessary, then click SET LONGITUDE. Click OK in the box that appears.

v) **GMT**: Look at the GMT display. Make corrections if necessary, then click SET GMT. Click OK in the box that appears.

vi) **Click OK to close the box**.

4. **Synchronizing the mount with *TheSky***. This is the procedure that will tell *TheSky* where your telescope is pointing. Your telescope should be polar aligned. If not, be sure that the polar axis is pointing approximately towards the pole (you can sight through the hole for the polar alignment scope. Polaris should be roughly visible through this hole).

a) **Point your telescope to a known star**.

b) **Center the star in your eyepiece manually**.

c) **Using *TheSky*, move the cursor to the location of this star on the star map. Click on the star**. The "Object Information" dialog box will appear.

d) **Click on SYNCH**. A dialog box will display "Confirm sync:" and will display the RA and Dec coordinates.

e) **Click OK and close the "Object Information" box**. At this point, the crosshair circle on the screen will be located at the star that you have synched on. If you are already polar aligned, you are ready to use *TheSky* as usual.

5. **Polar aligning with *TheSky*.** If you are not polar aligned, follow this procedure. For the most accurate polar alignment, alternate between two stars and Polaris- one in the east and one in the west, far apart. Ideally, the star should be located on the Celestial Equator line. You can see this on your computer screen.

a) **Place your cursor on Polaris and click on it**. The "Object Information" box will display. Be sure that the star you have clicked on is highlighted in the Object List. You may have accidentally clicked on another object nearby. If it is not highlighted, do so now.

b) **Click SLEW TO**.

c) **Look in your eyepiece**. If Polaris is not in the center of the eyepiece, adjust the azimuth and altitude on the mount to place Polaris in the center of the eyepiece.

d) **Click on another known star**.

e) **Click SLEW TO**. Center star manually in the eyepiece.

f) **Slew back to Polaris**. Adjust azimuth and altitude to center Polaris.

g) **Repeat as often as necessary** until you are now polar aligned.

6. Proceed using *TheSky* as usual.

APPENDIX A -CONSTELLATION ABBREVIATIONS

And	Andromeda
Ant	Antlia
Aps	Apus
Aqr	Aquarius
Aql	Aquila
Ara	Ara
Ari	Aries
Aur	Auriga
Boo	Boötes
Cae	Caelum
Cam	Camelopardalis
Cnc	Cancer
CVn	Canes Venatici
CMa	Canis Major
CMi	Canis Minor
Cap	Capricornus
Car	Carina
Cas	Cassiopeia
Cen	Centaurus
Cep	Cepheus
Cet	Cetus
Cha	Chamaeleon
Cir	Circinus
Col	Columba
Com	Coma Berenices
CrA	Corona Australis
CrB	Corona Borealis
Crv	Corvus
Crt	Crater
Cru	Crux
Cyg	Cygnus
Del	Delphinus
Dor	Dorado
Dra	Draco
Equ	Equuleus
Eri	Eridanus
For	Fornax
Gem	Gemini
Gru	Grus
Her	Hercules
Hor	Horologium
Hya	Hydra
Hyi	Hydrus
Ind	Indus
Lac	Lacerta
Leo	Leo
LMi	Leo Minor
Lep	Lepus
Lib	Libra
Lup	Lupus
Lyn	Lynx
Lyr	Lyra
Men	Mensa
Mic	Microscopium
Mon	Monoceros
Mus	Musca
Nor	Norma
Oct	Octans
Oph	Ophiuchus
Ori	Orion
Pav	Pavo
Peg	Pegasus
Per	Perseus
Phe	Phoenix
Pic	Pictor
Psc	Pisces
PsA	Piscis Austrinus
Pup	Puppis
Pyx	Pyxis
Ret	Reticulum
Sge	Sagitta
Sgr	Sagittarius
Sco	Scorpius
Sci	Sculptor
Sct	Scutum
Ser	Serpens
Sex	Sextans
Tau	Taurus
Tel	Telescopium
Tri	Triangulum
TrA	Triangulum Australe
Tuc	Tucana
UMa	Ursa Major
UMi	Ursa Minor
Vel	Vela
Vir	Virgo
Vol	Volans
Vul	Vulpecula

APPENDIX B – ALPHABETICAL STAR LIST

These stars are listed in the same order as they appear on your display when you are either following the calibration routine or have chosen Stars from the Objects Menu . Note that Polaris appears twice.

Common Name	Flamsteed-Bayer Designation	Abbrev.	Magnitude (SAO)
Polaris	Alpha Ursae Minoris	Alf UMi	2.1
Acamar	Theta Eridani	Tet Eri	3.2
Achernar	Alpha Eridani	Alf Eri	0.6
Acrux	Alpha2 Crucis	Alf Cru	1.6
Acubens	65-Alpha Cancri	Alf Cnc	4.3
Adhafera	36-Zeta Leonis	Zet Leo	3.6
Adhara	21-Epsilon Canis Majoris	Eps CMa	1.6
Albali	2-Epsilon Aquarii	Eps Aqr	3.8
Albireo	6-Beta1 Cygni	Bet Cyg	3.2
Alchiba	1-Alpha Corvi	Alf Crv	4.2
Alcor	80 Ursae Majoris	80 UMa	4.0
Alcyone	25-Eta Tauri	Eta Tau	3.0
Aldebaran	87-Alpha Tauri	Alf Tau	1.1
Alderamin	5-Alpha Cephei	Alf Cep	2.6
Alfirk	8-Beta Cephei	Bet Cep	3.3
Algedi	6-Alpha2 Capricorni	Alf Cap	3.8
Algenib	88-Gamma Pegasi	Gam Peg	2.9
Algieba	41-Gamma2 Leonis	Gam Leo	2.6
Algol	26-Beta Persei	Bet Per	2.9
Algorab	7-Delta Corvi	Del Crv	3.1
Alhena	24-Gamma Geminorum	Gam Gem	1.9
Alioth	77-Epsilon Ursae Majoris	Eps UMa	1.7
Alkaid	85-Eta Ursae Majoris	Eta UMa	1.9
Alkalurops	51-Mu1 Boötis	Mu Boo	4.5
Alkes	7-Alpha Crateris	Alf Crt	4.2
Almach	57-Gamma1 Andromedae	Gam And	2.3
AlNair	Alpha Gruis	Alf Gru	2.2
Alnasl	10-Gamma2 Sagittarii	Gam Sgr	3.1
Alnilam	46-Epsilon Orionis	Eps Ori	1.8
Alnitak	50-Zeta Orionis	Zet Ori	2.0
Alpha Centauri	Alpha1 Centauri	Alf Cen	0.1
Alphard	30-Alpha Hydrae	Alf Hya	2.2
Alphecca	5-Alpha Coronae Borealis	Alf CrB	2.3
Alpheratz	21-Alpha Andromedae	Alf And	2.1
Alrakis	21-Mu Draconis	Mu Dra	5.1
Alrescha	113-Alpha Piscium	Alf Psc	4.3
Alshain	60-Beta Aquilae	Bet Aql	3.9
Altair	53-Alpha Aquilae	Alf Aql	0.9
Altais	57-Delta Draconis	Del Dra	3.2

Alterf	4-Lambda Leonis	Lam Leo	4.5
Aludra	31-Eta Canis Majoris	Eta CMa	2.4
Alula Australis	53-Xi Ursae Majoris	Xi UMa	3.9
Alula Borealis	54-Nu Ursae Majoris	Nu UMa	3.7
Alya	63-Theta Serpentis	Tet Ser	4.5
Ankaa	Alpha Phoenicis	Alf Phe	2.4
Antares	21-Alpha Scorpii	Alf Sco	1.1
Arcturus	16-Alpha Boötis	Alf Boo	0.2
Arkab	Beta1 Sagittarii	Bet Sgr	4.3
Arneb	11-Alpha Leporis	Alf Lep	2.7
Ascella	38-Zeta Sagittarii	Zet Sgr	2.7
Asellus Australis	47-Delta Cancri	Del Cnc	4.2
Asellus Borealis	43-Gamma Cancri	Gam Cnc	4.7
Aspidiske	Iota Carinae	Iot Car	2.3
Atik	44-Zeta Persei	Zet Per	2.9
Atlas	27 Tauri	27 Tau	3.8
Atria	Alpha Trianguli Australis	Alf TrA	1.9
Avior	Epsilon Carinae	Eps Car	1.7
Azha	3-Eta Eridani	Eta Eri	4.0
Baten Kaitos	55-Zeta Ceti	Zet Cet	3.9
Beid	38-Omicron Eridani	Omi Eri	4.1
Bellatrix	24-Gamma Orionis	Gam Ori	1.7
Betelgeuse	58-Alpha Orionis	Alf Ori	0.6
Biham	26-Theta Pegasi	Tet Peg	3.7
Canopus	Alpha Carinae	Alf Car	-0.9
Capella	Alpha Aurigae	Alf Aur	0.1
Caph	Beta Cassiopeiae	Bet Cas	2.3
Castor	66-Alpha Germinorum	Alf Gem	1.6
Cebalrai	60-Beta Ophiuchi	Bet Oph	2.9
Celaeno	16 Tauri	16 Tau	5.4
Chara	8-Beta Canum Venaticorum	Bet CVn	4.3
Chertan	70-Theta Leonis	Tet Leo	3.4
Cor Caroli	12-Alpha2 Canum Venaticorum	Alf CVn	2.9
Cursa	67-Beta Eridani	Bet Eri	2.9
Dabih	9-Beta1 Capricorni	Bet Cap	3.3
Deneb	50-Alpha Cygni	Alf Cyg	1.3
Deneb Algedi	49-Delta Capricorni	Del Cap	3.0
Denebola	94-Beta Leonis	Bet Leo	2.2
Diphda	16-Beta Ceti	Bet Cet	2.2
Double Double			6.0
Dubhe	50-Alpha Ursae Majoris	Alf UMa	2.0
Edasich	12-Iota Draconis	Iot Dra	3.5
Electra	17 Tauri	17 Tau	3.8
Elnath	112-Beta Tauri	Bet Tau	1.8

Eltanin	33-Gamma Draconis	Gam Dra	2.4
Enif	8-Epsilon Pegasi	Eps Peg	2.5
Errai	35-Gamma Cephei	Gam Cep	3.4
Fomalhaut	24-Alpha Piscis Austrini	Alf PsA	1.3
Furud	1-Zeta Canis Majoris	Zet CMa	3.1
Gacrux	Gamma Crucis	Gam Cru	1.6
Giausar	1-Lambda Draconis	Lam Dra	4.1
Gienah	4-Gamma Corvi	Gam Crv	2.8
Gomeisa	3-Beta Canis Minoris	Bet CMi	3.1
Graffias	8-Beta Scorpii	Bet Sco	2.9
Grumium	32-Xi Draconis	Xi Dra	3.9
Hadar	Beta Centauri	Bet Cen	0.9
Hamal	13-Alpha Arietis	Alf Ari	2.2
Hinds Crimson Star			6.0
Homam	42-Zeta Pegasi	Zet Peg	3.6
Izar	36-Epsilon Boötis	Eps Boo	2.7
Kaffaljidhma	86-Gamma Ceti	Gam Cet	3.6
Kaus Australis	20-Epsilon Sagittarii	Eps Sgr	2.0
Kaus Borealis	22-Lambda Sagittarii	Lam Sgr	2.9
Kaus Media	19-Delta Sagittarii	Del Sgr	2.8
Keid	40-Omicron2 Eridani	Omi Eri	4.5
Kitalpha	8-Alpha Equulei	Alf Equ	4.1
Kochab	7-Beta Ursae Minoris	Bet UMi	2.2
Kornephoros	27-Beta Herculis	Bet Her	2.8
Kurhah	17-Xi Cephei	Xi Cep	4.6
Lesath	34-Upsilon Scorpii	Ups Sco	2.8
Maia	20 Tauri	20 Tau	3.9
Marfik	10-Lambda Ophiuchi	Lam Oph	3.9
Markab	54-Alpha Pegasi	Alf Peg	2.6
Matar	44-Eta Pegasi	Eta Peg	3.1
Mebsuta	27-Epsilon Geminorum	Eps Gem	3.2
Megrez	69-Delta Ursae Majoris	Del UMa	3.4
Meissa	39-Lambda Orionis	Lam Ori	3.7
Mekbuda	43-Zeta Geminorum	Zet Gem	3.9
Menkalinan	34-Beta Aurigae	Bet Aur	2.1
Menkar	92-Alpha Ceti	Alf Cet	2.8
Menkent	5-Theta Centauri	Tet Cen	2.3
Menkib	46-Xi Persei	Xi Per	4.0
Merak	48-Beta Ursae Majoris	Bet UMa	2.4
Merope	23 Tauri	23 Tau	4.3
Mesarthim	5-Gamma1 Arietis	Gam Ari	4.8
Miaplacidus	Beta Carinae	Bet Car	1.8
Mimosa	Beta Crucis	Bet Cru	1.5
Mintaka	34-Delta Orionis	Del Ori	2.5

Mira	Omicron Ceti	Omi Cet	2.1
Mirach	43-Beta Andromedae	Bet And	2.4
Mirfak	33-Alpha Persei	Alf Per	1.9
Mirzam	2-Beta Canis Majoris	Bet CMa	2.0
Mizar	79-Zeta Ursae Majoris	Zet UMa	2.4
Muphrid	8-Eta Boötis	Eta Boo	2.8
Muscida	1-Omicron Ursae Majoris	Omi UMa	3.5
Nashira	40-Gamma Capricorni	Gam Cap	3.8
Navi	27-Gamma Cassiopeiae	Gam Cas	2.8
Nekkar	42-Beta Boötis	Bet Boo	3.6
Nihal	9-Beta Leporis	Bet Lep	3.0
Nunki	34-Sigma Sagittarii	Sig Sgr	2.1
Nusakan	3-Beta Coronae Borealis	Bet CrB	3.7
Peacock	Alpha Pavonis	Alf Pav	2.1
Phact	Alpha Columbae	Alf Col	2.8
Phecda	64-Gamma Ursae Majoris	Gam UMa	2.5
Pherkad	13-Gamma Ursae Minoris	Gam UMi	3.1
Pleione	28 Tauri	28 Tau	5.2
Polaris	1-Alpha Ursae Minoris	Alf UMi	2.1
Pollux	78-Beta Geminorum	Bet Gem	1.2
Porrima	29-Gamma Virginis	Gam Vir	2.9
Procyon	10-Alpha Canis Minoris	Alf CMi	0.5
Propus	Eta Geminorum	Eta Gem	3.3
Rasalas	24-Mu Leonis	Mu Leo	4.1
Rasalgethi	64-Alpha Herculis	Alf Her	3.5
Rasalhague	55-Alpha Ophiuchi	Alf Oph	2.1
Rastaban	23-Beta Draconis	Bet Dra	3.0
Regor	Gamma2 Velorum	Gam Vel	1.9
Regulus	32-Alpha Leonis	Alf Leo	1.3
Rigel	19-Beta Orionis	Bet Ori	0.3
Ruchbah	37-Delta Cassiopeiae	Del Cas	2.7
Rukbat	Alpha Sagittarii	Alf Sgr	4.1
Sabik	35-Eta Ophiuchi	Eta Oph	2.6
Sadalmelik	34-Alpha Aquarii	Alf Aqr	3.2
Sadalsuud	22-Beta Aquarii	Bet Aqr	3.1
Sadr	37-Gamma Cygni	Gam Cyg	2.3
Saiph	53-Kappa Orionis	Kap Ori	2.2
Scheat	53-Beta Pegasi	Bet Peg	2.6
Schedar	18-Alpha Cassiopeiae	Alf Cas	2.5
Seginus	27-Gamma Boötis	Gam Boo	3.0
Shaula	35-Lambda Scorpii	Lam Sco	1.7
Sheliak	10-Beta Lyrae	Bet Lyr	3.9
Sheratan	6-Beta Arietis	Bet Ari	2.7
Sirius	9-Alpha Canis Majoris	Alf CMa	-1.6

Skat	76-Delta Aquarii	Del Aqr	3.5
Spica	67-Alpha Virginis	Alf Vir	1.2
Sterope	21 Tauri	21 Tau	5.9
Suhail	Lambda Velorum	Lam Vel	2.2
Sulafat	14-Gamma Lyrae	Gam Lyr	3.3
Syrma	99-Iota Virginis	Iot Vir	4.2
Talitha	9-Iota Ursae Majoris	Iot UMa	3.1
Tania Australis	34-Mu Ursae Majoris	Mu UMa	3.2
Tania Borealis	33-Lambda Ursae Majoris	Lam UMa	3.5
Tarazed	50-Gamma Aquilae	Gam Aql	2.8
Taygeta	19 Tauri	19 Tau	4.4
Thuban	11-Alpha Draconis	Alf Dra	3.6
Trapezium	41-Theta1 Orionis	Tet Ori	5.4
Unukalhai	24-Alpha Serpentis	Alf Ser	2.8
UU	none	none	5.1
Vega	3-Alpha Lyrae	Alf Lyr	0.1
Vindemiatrix	47-Epsilon Virginis	Eps Vir	3.0
Wasat	55-Delta Geminorum	Del Gem	3.5
Wazn	Beta Columbae	Bet Col	3.2
Wezen	25-Delta Canis Majoris	Del CMa	2.0
Yed Posterior	2-Epsilon Ophiuchi	Eps Oph	3.3
Yed Prior	1-Delta Ophiuchi	Del Oph	3.0
Zaniah	15-Eta Virginis	Eta Vir	4.0
Zaurak	34-Gamma Eridani	Gam Eri	3.2
Zavijava	5-Beta Virginis	Bet Vir	3.8
Zosma	68-Delta Leonis	Del Leo	2.6
Zubenelgenubi	9-Alpha2 Librae	Alf Lib	2.9
Zubeneschamali	27-Beta Librae	Bet Lib	2.7

Sun

APPENDIX C: COMMON STARS – BY CONSTELLATION

Constellation	Star Name	Flamsteed-Bayer Designation	Abbrev	Magnitude(SAO)
Andromeda				
	Alpheratz	21-Alpha Andromedae	Alf And	2.1
	Mirach	43-Beta Andromedae	Bet And	2.4
	Almach	57-Gamma1 Andromedae	Gam And	2.3
Aquarius				
	Sadalmelik	34-Alpha Aquarii	Alf Aqr	3.2
	Sadalsuud	22-Beta Aquarii	Bet Aqr	3.1
	Skat	76-Delta Aquarii	Del Aqr	3.5
	Albali	2-Epsilon Aquarii	Eps Aqr	3.8
Aquila				
	Altair	53-Alpha Aquilae	Alf Aql	0.9
	Alshain	60-Beta Aquilae	Bet Aql	3.9
	Tarazed	50-Gamma Aquilae	Gam Aql	2.8
Aries				
	Hamal	13-Alpha Arietis	Alf Ari	2.2
	Sheratan	6-Beta Arietis	Bet Ari	2.7
	Mesarthim	5-Gamma2 Arietis	Gam Ari	4.8
Auriga				
	Capella	Alpha Aurigae	Alf Aur	0.1
	Menkalinan	34-Beta Aurigae	Bet Aur	2.1
Boötes				
	Arcturus	16-Alpha Boötis	Alf Boo	0.2
	Nekkar	42-Beta Boötis	Bet Boo	3.6
	Seginus	27-Gamma Boötis	Gam Boo	3.0
	Izar	36-Epsilon Boötis	Eps Boo	2.7
	Muphrid	8-Eta Boötis	Eta Boo	2.8
	Alkalurops	51-Mu1 Boötis	Mu Boo	4.5
Cancer				
	Acubens	65-Alpha Cancri	Alf Cnc	4.3
	Asellus Borealis	43-Gamma Cancri	Gam Cnc	4.7
	Asellus Australis	47-Delta Cancri	Del Cnc	4.2
Canis Major				
	Sirius	9-Alpha Canis Majoris	Alf CMa	-1.6
	Mirzam	2-Beta Canis Majoris	Bet CMa	2.0
	Wezen	25-Delta Canis Majoris	Del CMa	2.0
	Adhara	21-Epsilon Canis Majoris	Eps CMa	1.6
	Furud	1-Zeta Canis Majoris	Zet CMa	3.1
	Aludra	31-Eta Canis Majoris	Eta CMa	2.4
Canis Minor				
	Procyon	10-Alpha Canis Minoris	Alf CMi	0.5

	Gomeisa	3-Beta Canis Minoris	Bet CMi	3.1
Canis Venatici				
	Cor Caroli	12-Alpha Canum Venaticorum	Alf CVn	2.9
	Chara	8-Beta Canum Venaticorum	Bet CVn	4.3
Capricornus				
	Algedi	6-Alpha2 Capricorni	Alf Cap	3.8
	Dabih	9-Beta1 Capricorni	Bet Cap	3.3
	Nashira	40-Gamma Capricorni	Gam Cap	3.8
	Deneb Algedi	49-Delta Capricorni	Del Cap	3.0
Carina				
	Canopus	Alpha Carinae	Alf Car	-0.9
	Miaplacidus	Beta Carinae	Bet Car	1.8
	Avior	Epsilon Carinae	Eps Car	1.7
	Aspidiske	Iota Carinae	Iot Car	2.3
Cassiopeia				
	Schedar	18-Alpha Cassiopeiae	Alf Cas	2.5
	Caph	Beta Cassiopeia	Bet Cas	2.3
	Navi	27-Gamma Cassiopeiae	Gam Cas	2.8
	Ruchbah	37-Delta Cassiopeiae	Del Cas	2.7
Centaurus				
	Alpha Centauri	Alpha1 Centauri	Alf Cen	0.1
	Hadar	Beta Centauri	Bet Cen	0.9
	Menkent	5-Theta Centauri	Tet Cen	2.3
Cepheus				
	Alderamin	5-Alpha Cephei	Alf Cep	2.6
	Alfirk	8-Beta Cephei	Bet Cep	3.3
	Erral	35-Gamma Cephei	Gam Cep	3.4
	Kurhah	17-Xi Cephei	Xi Cep	4.6
Cetus				
	Menkar	92-Alpha Ceti	Alf Cet	2.8
	Diphda	16-Beta Ceti	Bet Cet	2.2
	Kaffaljidhma	86-Gamma Ceti	Gam Cet	3.6
	Baten Kaitos	55-Zeta Ceti	Zet Cet	3.9
	Mira	Omicron Ceti	Omi Cet	2.1
Columba				
	Phact	Alpha Columbae	Alf Col	2.8
	Wazn	Beta Columbae	Bet Col	3.2
Corona Borealis				
	Alphecca	5-Alpha Coronae Borealis	Alf CrB	2.3
	Nusakan	3-Beta Coronae Borealis	Bet CrB	3.7
Corvus				
	Alchiba	1-Alpha Corvi	Alf Crv	4.2
	Gienah	4-Gamma Corvi	Gam Crv	2.8
	Algorab	7-Delta Corvi	Del Crv	3.1

Crater				
	Alkes	7-Alpha Crateris	Alf Crt	4.2
Crux				
	Acrux	Alpha2 Crucis	Alf Cru	1.6
	Mimosa	Beta Crucis	Bet Cru	1.5
	Gacrux	Gamma Crucis	Gam Cru	1.6
Cygnus				
	Deneb	50-Alpha Cygni	Alf Cyg	1.3
	Albireo	6-Beta1 Cygni	Bet Cyg	3.2
	Sadr	37-Gamma Cygni	Gam Cyg	2.3
Draco				
	Thuban	11-Alpha Draconis	Alf Dra	3.6
	Rastaban	23-Beta Draconis	Bet Dra	3.0
	Eltanin	33-Gamma Draconis	Gam Dra	2.4
	Altais	57-Delta Draconis	Del Dra	3.2
	Edasich	12-Iota Draconis	Iot Dra	3.5
	Giausar	1-Lambda Draconis	Lam Dra	4.1
	Alrakis	21-Mu Draconis	Mu Dra	5.1
	Grumium	32-Xi Draconis	Xi Dra	3.9
Equuleus				
	Kitelpha	8-Alpha Equulei	Alf Equ	4.1
Eridanus				
	Achernar	Alpha Eridani	Alf Eri	0.6
	Cursa	67-Beta Eridani	Bet Eri	2.9
	Zaurak	34-Gamma Eridani	Gam Eri	3.2
	Azha	3-Eta Eridani	Eta Eri	4.0
	Acamar	Theta Eridani	Tet Eri	3.2
	Beid	38-Omicron Eridani	Omi Eri	4.1
	Keid	40-Omicron2 Eridani	Omi Eri	4.5
Gemini				
	Castor	66-Alpha Geminorum	Alf Gem	1.6
	Pollux	78-Beta Geminorum	Bet Gem	1.2
	Alhena	24-Gamma Geminorum	Gam Gem	1.9
	Wasat	55-Delta Geminorum	Del Gem	3.5
	Mebsuta	27-Epsilon Geminorum	Eps Gem	3.2
	Mekbuda	43-Zeta Geminorum	Zet Gem	3.9
	Propus	Eta Geminorum	Eta Gem	3.3
Grus				
	AlNair	Alpha Gruis	Alf Gru	2.2
Hercules				
	Rasalgethi	64-Alpha Herculis	Alf Her	3.5
	Kornephoros	27-Beta Herculis	Bet Her	2.8
Hydra				
	Alphard	30-Alpha Hydrae	Alf Hya	2.2

Leo				
	Regulus	32-Alpha Leonis	Alf Leo	1.3
	Denebola	94-Beta Leonis	Bet Leo	2.2
	Algieba	41-Gamma2 Leonis	Gam Leo	2.6
	Zosma	68-Delta Leonis	Del Leo	2.6
	Adhafera	36-Zeta Leonis	Zet Leo	3.6
	Alterf	4-Lambda Leonis	Lam Leo	4.5
	Chertan	70-Theta Leonis	Tet Leo	3.4
	Rasalas	24-Mu Leonis	Mu Leo	4.1
	Arneb	11-Alpha Leporis	Alf Lep	2.7
	Nihal	9-Beta Leporis	Bet Lep	3.0
Libra				
	Zubenelgenubi	9-Alpha2 Librae	Alf Lib	2.9
	Zubeneschamali	27-Beta Librae	Bet Lib	2.7
Lyra				
	Vega	3-Alpha Lyrae	Alf Lyr	0.1
	Sheliak	10-Beta Lyrae	Bet Lyr	3.9
	Sulafat	14-Gamma Lyrae	Gam Lyr	3.3
Ophiuchus				
	Rasalhague	55-Alpha Ophiuchi	Alf Oph	2.1
	Cebalrai	60-Beta Ophiuchi	Bet Oph	2.9
	Yed Prior	1-Delta Ophiuchi	Del Oph	3.0
	Yed Posterior	2-Epsilon Ophiuchi	Eps Oph	3.3
	Sabik	35-Eta Ophiuchi	Eta Oph	2.6
	Marfik	10-Lambda Ophiuchi	Lam Oph	3.9
Orion				
	Betelgeuse	58-Alpha Orionis	Alf Ori	0.6
	Rigel	19-Beta Orionis	Bet Ori	0.3
	Bellatrix	24-Gamma Orionis	Gam Ori	1.7
	Alnilam	46-Epsilon Orionis	Eps Ori	1.8
	Mintaka	34-Delta Orionis	Del Ori	2.5
	Alnitak	50-Zeta Orionis	Zet Ori	2.0
	Trapezium	41-Theta1 Orionis	Tet Ori	5.4
	Saiph	53-Kappa Orionis	Kap Ori	2.2
	Meissa	39-Lambda Orionis	Lam Ori	3.7
Pavo				
	Peacock	Alpha Pavonis	Alf Pav	2.1
Pegasus				
	Markab	54-Alpha Pegasi	Alf Peg	2.6
	Scheat	53-Beta Pegasi	Bet Peg	2.6
	Algenib	88-Gamma Pegasi	Gam Peg	2.9
	Enif	8-Epsilon Pegasi	Eps Peg	2.5
	Homam	42-Zeta Pegasi	Zet Peg	3.6
	Matar	44-Eta Pegasi	Eta Peg	3.1

	Biham	26-Theta Pegasi	Tet Peg	3.7
Perseus				
	Mirfak	33-Alpha Persei	Alf Per	1.9
	Algol	26-Beta Persei	Bet Per	2.9
	Atik	44-Zeta Persei	Zet Per	2.9
	Menkib	46-Xi Persei	Xi Per	4.0
Phoenix				
	Ankaa	Alpha Phoenicis	Alf Phe	2.4
Pisces				
	Alrescha	113-Alpha Piscium	Alf Psc	4.3
Piscis Austrinus				
	Fomalhaut	24-Alpha Piscis Austrini	Alf PsA	1.3
Sagittarius				
	Rukbat	Alpha Sagittarii	Alf Sgr	4.1
	Arkab	Beta1 Sagittarii	Bet Sgr	4.3
	Alnasi	10-Gamma2 Sagittarii	Gam Sgr	3.1
	Kaus Media	19-Delta Sagittarii	Del Sgr	2.8
	Kaus Australis	20-Epsilon Sagittarii	Eps Sgr	2.0
	Ascella	38-Zeta Sagittarii	Zet Sgr	2.7
	Kaus Borealis	22-Lambda Sagittarii	Lam Sgr	2.9
	Nunki	34-Sigma Sagittarii	Sig Sgr	2.1
Scorpius				
	Antares	21-Alpha Scorpii	Alf Sco	1.1
	Graffias	8-Beta Scorpii	Bet Sco	2.9
	Shaula	35-Lambda Scorpii	Lam Sco	1.7
	Lesath	34-Upsilon Scorpii	Ups Sco	2.8
Serpens				
	Unukalhai	24-Alpha Serpentis	Alf Ser	2.8
	Alya	63-Theta Serpentis	Tet Ser	4.5
Taurus				
	Aldebaran	87-Alpha Tauri	Alf Tau	1.1
	Elnath	112-Beta Tauri	Bet Tau	1.8
	Alcyone	25-Eta Tauri	Eta Tau	3.0
	Celaeno	16 Tauri	16 Tau	5.4
	Electra	17 Tauri	17 Tau	3.8
	Taygeta	19 Tauri	19 Tau	4.4
	Maia	20 Tauri	20 Tau	3.9
	Sterope	21 Tauri	21 Tau	5.9
	Merope	23 Tauri	23 Tau	4.3
	Atlas	27 Tauri	27 Tau	3.8
	Pleione	28 Tauri	28 Tau	5.2
Triangulum Australe				
	Atria	Alpha Trianguli Australis	Alf TrA	1.9
Ursa Major				

	Dubhe	50-Alpha Ursae Majoris	Alf UMa	2.0
	Merak	48-Beta Ursae Majoris	Bet UMa	2.4
	Phecda	64-Gamma Ursae Majoris	Gam UMa	2.5
	Alioth	77-Delta Ursae Majoris	Eps UMa	1.7
	Megrez	69-Delta Ursae Majoris	Del UMa	3.4
	Mizar	79-Zeta Ursae Majoris	Zet UMa	2.4
	Alkaid	85-Eta Ursae Majoris	Eta UMa	1.9
	Talitha	9-Iota Ursae Majoris	Iot UMa	3.0
	Tania Borealis	33-Lambda Ursae Majoris	Lam UMa	3.5
	Tania Australis	34-Mu Ursae Majoris	Mu UMa	3.2
	Alula Borealis	54-Nu Ursae Majoris	Nu UMa	3.7
	Alula Australis	53-Xi Ursae Majoris	Xi UMa	3.9
	Muscida	1-Omicron Ursae Majoris	Omi UMa	3.5
	Alcor	80 Ursae Majoris	80 UMa	4.0
Ursa Minor				
	Polaris	1-Alpha Ursae Minoris	Alf UMi	2.1
	Kochab	7-Beta Ursae Minoris	Bet UMi	2.2
	Pherkad	13-Gamma Ursae Minoris	Gam UMi	3.1
Vela				
	Regor	Gamma2 Velorum	Gam Vel	1.9
	Suhail	Lambda Velorum	Lam Vel	2.2
Virgo				
	Spica	67-Alpha Virginis	Alf Vir	1.2
	Zavijava	5-Beta Virginis	Bet Vir	3.8
	Porrima	29-Gamma Virginis	Gam Vir	2.9
	Vindemaitrix	47-Epsilon Virginis	Eps Vir	3.0
	Zaniah	15-Eta Virginis	Eta Vir	4.0
	Syrma	99-Iota Virginis	Iot Vir	4.2

APPENDIX D - COMMON OBJECTS NAMES

These objects are listed in the order in which they appear on the screen.

47Tuc
Andromeda Galaxy
Antennae
Barnard's Galaxy
Baxendell's Nebula
Bear Paw Galaxy
Beehive Cluster
Black-eye Galaxy
Blinking Planetary
Blue Snowball
Blue Planetary
Bode's Nebula
Box
Box Nebula
Bubble Nebula
Bug Nebula
Butterfly Cluster
Butterfly Nebula
California Nebula
Christmas Tree Cluster
Cocoon Nebula
Cone Nebula
Copeland's Septet
Crab Nebula
Crescent Nebula
Double Cluster
Dumbell Nebula
Eagle Nebula
Eight-burst Planetary
Eskimo Nebula
The Eyes
Filamentary Nebula
Flaming Star Nebula
Ghost of Jupiter
Great Cluster in Hercules
Great Nebula in Andromeda
Great Nebula in Orion
Helix Galaxy
Helix Nebula
Hind's Variable Nebula
Horsehead Nebula
Hourglass Nebula
Hubble's Variable Nebula
Jewel Box
Lacework Nebula
Lagoon Nebula
Little Dumbell
Little Gem
Maia Nebula
Merope Nebula
The Mice
Network-1 Nebula
Network-2 Nebula
North American Nebula
Omega Nebula
Owl Nebula
Papillon
Pelican Nebula
Pin-wheel Nebula
Polarissima Australis
Polarissima Borealis
Praesepe
Ring Nebula in Lyra
Rosette Nebula
Saturn Nebula
Sculptor Galaxy
Siamese Twins
Sombrero Galaxy
Southern Pleiades
Spindle Galaxy
Star Queen Nebula
Stephan's Quintet
Struve's Lost Nebula
Sunflower Galaxy
Tarantula Nebula
Toby Jug Nebula
Triangulum Galaxy
Trifid Nebula
Veil Nebula
Whirlpool Galaxy
Wild Duck Cluster
Witch Head Nebula
Eta Carina Nebula
Gamma Cas Nebula
Gamma Cygnus Nebula
Kappa Cru Cluster
Lambda-1 Cen Nebula
Lambda-2 Cen Nebula
Omega Cen
Rho Oph Nebula

APPENDIX E - AITKEN'S DOUBLE STAR (ADS) LIST

These commonly observed double stars were chosen from R. G. Aitken's New General Catalog of Double Stars. Please note that the separations are approximate and may vary from year to year. If you are an avid double star observer, please consult an ephemeris for the most accurate data.

ADS Number	Name	Separation
00111	Kappa1 Sci	1.4
00191	35 Psc	11.6
00434	Lambda Cas	0.6
00513	Pi And	35.9
00520	Beta 395 Cet	0.5
00558	55 Psc	6.5
00624	HN 122	36.1
00671	Eta Cas	12.9
00683	65 Psc	4.4
00755	36 And	0.9
00782	Gamma Cas	2.1
00899	Psi1 Psc	30.0
00996	Zeta Psc	23.0
01003	37 Cet	49.7
01081	42 Cet	1.6
01129	Psi Cas	25.0
01394	Epsilon Scl	4.7
01457	1 Air	2.8
01477	Alpha UMi	18.4
01507	Gamma Ari	7.8
01538	Sigma 186 Cet	1.1
01563	Lambda Ari	37.4
01598	48 Cas	0.9
01615	Alpha Psc	1.8
01630	Gamma And	9.8
01631	10 Ari	1.1
01683	59 And	16.6
01697	6 Tri	3.9
01703	66 Cet	16.5
01778	Omicron Cet	0.1
01860	Iota Cas	2.5
01954	Omega For	10.8
02080	Gamma Cet	2.8
02157	Eta Per	28.3
02200	20 Per	14.1
02257	Epsilon Ari	1.4
02312	Rho2 Eri	1.8
02362	Beta Per	81.0
02402	Alpha For	5.1
02616	7 Tau	0.8
02799	Omicron Sigma 65 Tau	0.2
02843	Zeta Per	12.9
02867	Omicron Sigma 67 Cam	12.9
02888	Epsilon Per	8.8
03079	39 Eri	6.4
03093	Omicron2 Eri	83.4
03137	Phi Tau	52.1
03161	Chi Tau	19.4
03321	Alpha Tau	121.7
03572	Omega Aur	5.4
03797	Rho Ori	7.0
03800	Kappa Lep	2.6
03823	Beta Ori	9.5
04002	Eta Ori	1.5
04066	Beta Lep	2.5
04134	Delta Ori	52.6
04177	19 Cam	1.3
04179	Lambda Ori	4.4
04186	Theta1 Ori	
04241	Sigma Ori	0.2
04263	Zeta Ori	2.3
04334	Gamma Lep	96.3
04566	Theta Aur	3.6
04773	41 Aur	7.7
04841	Eta Gem	1.6
04990	Mu Gem	121.7
05012	Epsilon Mon	13.4
05107	Beta Mon	7.3
05166	20 Gem	20.0
05253	Nu1 CMa	17.5
05400	12 Lyn	1.7
05423	Alpha CMa	4.6
05514	14 Lyn	0.4
05559	38 Gem	5.2
05605	Mu CMa	3.0
05654	Epsilon CMa	7.5

ADS Number	Name	Separation
05961	Lambda Gem	9.6
05983	Delta Gem	5.8
06101	Eta CMi	4.0
06175	Alpha Gem	3.9
06190	n Pup	9.6
06255	k Pup	9.9
06321	Kappa Gem	7.1
06420	9 Pup	0.2
06650	Zeta Cnc	6.0
06724	Sigma 1193 UMa	43.1
06815	Phi2 Cnc	5.1
06914	Beta 208 Pyx	1.6
06988	Iota Cnc	30.5
06993	Epsilon Hya	2.7
07114	Iota UMa	2.0
07203	Sigma2 UMa	3.9
07292	38 Lyn	2.7
07307	Sigma 1338 Lyn	1.0
07351	Kappa Leo	2.1
07390	Omega Leo	0.6
07402	23 UMa	22.7
07545	Phi UMa	0.3
07555	Gamma Sex	0.6
07654	Alpha Leo	176.9
07724	Gamma Leo	4.4
07846	Beta 411 Hya	1.4
08119	Xi UMa	1.8
08123	Nu UMa	7.2
08148	Iota Leo	1.7
08153	Gamma Crt	5.2
08175	57 UMa	5.4
08196	88 Leo	8.4
08197	Omicron Sigma 235 UMa	0.6
08406	2 Com	3.7
08539	Sigma 1639 Com	1.7
08572	Delta Crv	24.2
08573	Beta 28 Crv	2.2
08600	24 Com	20.3
08630	Gamma Vir	1.8
08682	Sigma 1694 Cam	21.6
08695	35 Com	1.2
08706	Alpha CVn	19.4
08801	Theta Vir	7.1
08891	Zeta UMa	14.4
08974	25 CVn	1.8
09000	84 Vir	2.9
09025	Tau Boo	4.8
09085	Tau Vir	80.0
09173	Kappa Boo	13.4
09198	Iota Boo	38.5
09273	Phi Vir	4.8
09338	Pi Boo	5.6
09343	Zeta Boo	0.8
09372	Epsilon Boo	2.8
09396	Mu Lib	1.8
09406	39 Boo	2.9
09413	Xi Boo	6.6
09425	Omicron Sigma 288 Boo	0.8
09494	44,i Boo	2.2
09532	Iota1 Lib	57.8
09584	5 Ser	11.2
09617	Eta CrB	0.8
09626	Mu Boo	108.3
09701	Delta Ser	4.4
09737	Zeta CrB	6.3
09909	Xi Sco	0.4
09913	Beta Sco	13.6
09951	Nu Sco	41.1
09979	Alpha CrB	7.1
10049	Rho Oph	3.1
10058	Eta Dra	5.2
10074	Alpha Sco	2.6
10087	Lambda Oph	1.5
10157	Zeta Her	0.8
10279	20 Dra	1.3
10345	Mu Dra	1.9
10418	Alpha Her	4.6
10424	Delta Her	8.9
10526	Rho Her	4.1
10628	Nu Dra	61.9
10660	26 Dra	1.7
10759	Psi1 Dra	30.3
10786	Mu Her	33.8
10875	90 Her	1.6

ADS Number	Name	Separation
11005	Tau Oph	1.7
11046	70 Oph	4.5
11061	40/41 Dra	19.3
11483	Omicron Sigma 358 Her	1.3
11635	Epsilon Lyr	207.7
11639	Zeta Lyr	43.7
11745	Beta Lyr	45.7
11853	Theta Ser	22.3
12197	Eta Lyr	28.1
12540	Beta Cyg	34.4
12789	Sigma 2573 Dra	18.2
12880	Delta Cyg	2.5
12962	Pi Aql	1.4
13007	Epsilon Dra	3.1
13148	Psi Cyg	3.2
13371	Sigma 2640 Dra	5.6
13442	Theta Sge	11.9
13524	Kappa Cep	7.4
13632	Alpha1 Cap	45.4
13645	Alpha2 Cap	6.6
13765	Gamma Cyg	41.2
13887	Rho Cap	0.5
14158	49 Cyg	2.7
14259	52 Cyg	6.0
14279	Gamma Del	9.6
14296	Lambda Cyg	0.9
14360	4 Aqr	0.8
14499	Epsilon Equ	0.8
14636	61 Cyg	30.3
14787	Tau Cyg	0.8
15032	Beta Cep	13.3
15270	Mu Cyg	1.2
15281	Kappa Peg	0.2
15536	Eta PsA	1.7
15600	Xi Cep	8.2
15719	Sigma 2883 Cep	14.6
15753	41 Aqr	5.0
15764	Sigma 2893 Cep	28.9
15828	Sigma 2894 Lac	15.6
15934	53 Aqr	3.1
15971	Zeta Aqr	2.1
15987	Delta Cep	41.0
16095	8 Lac	22.4
16261	Xi Peg	11.5
16268	Tau1 Aqr	23.7
16538	Pi Cep	1.1
16633	Psi1 Aqr	49.6
16666	Omicron Cep	2.8
16672	94 Aqr	12.7
16836	72 Peg	0.5
16957	78 Peg	1.0
16979	107 Aqr	6.6
17022	6 Cas	1.6
17140	Sigma Cas	3.0
17175	85 Peg	0.7

APPENDIX F - THE GREEK ALPHABET

We have included this list for your reference to help you translate Greek letter designations that may be used in your star atlas or other reference. The abbreviations are used in Stars/Constell Tour as described on page 12 and in

Symbol		Translation	Abbreviation
Α	α	Alpha	Alf
Β	β	Beta	Bet
Γ	γ	Gamma	Gam
Δ	δ	Delta	Del
Ε	ε	Epsilon	Eps
Ζ	ζ	Zeta	Zet
Η	η	Eta	Eta
Θ	θ	Theta	Tet
Ι	ι	Iota	Iot
Κ	κ	Kappa	Kap
Λ	λ	Lambda	Lam
Μ	μ	Mu	Mu
Ν	ν	Nu	Nu
Ξ	ξ	Xi	Xi
Ο	ο	Omicron	Omi
Π	π	Pi	Pi
Ρ	ρ	Rho	Rho
Σ	σ	Sigma	Sig
Τ	τ	Tau	Tau
Υ	υ	Upsilon	Ups
Φ	ϕ	Phi	Phi
Χ	χ	Chi	Chi
Ψ	ψ	Psi	Psi
Ω	ω	Omega	Ome

APPENDIX G – RS-232 COMMAND LANGUAGE

Last Modified: 5/17/99

These commands are the same as the Meade LX200 protocol:

Command: :Sr HH:MM.S# or :Sr HH:MM:SS#
Response: "1"

Defines the commanded Right Ascension, RA. Must be issued in order for the calibrate mount command to be accepted. Command may be issued in long or short format regardless of whether long format has been selected. Move and calibrate commands operate on the most recently defined RA. RA specified as DD*MM:SS will also be interpreted properly if greater precision is required, but this is not typically how RA is expressed.

Command: :Sd sDD*MM# or :Sd sDD*MM:SS#
Response: "1"

Defines the commanded Declination, DEC. Must be issued in order for the calibrate mount command to be accepted Command may be issued in long or short format regardless of whether long format has been selected. Move and calibrate commands operate on the most recently defined DEC.

Command: :SG sHH#
Response: "1"

Sets the offset from Greenwich mean time. Must be issued in order for the calibrate mount command to be accepted.

Command: :Sg DDD*MM# or :Sg DDD*MM:SS#
Response: "1"

Sets the current longitude. Must be issued in order for the calibrate mount command to be accepted. Command may be issued in long or short format regardless of whether long format has been selected.

Command: :St sDD*MM#
Response: "1"

Sets the current latitude. Must be issued in order for the calibrate mount command to be accepted. Command may be issued in long or short format regardless of whether long format has been selected.

Command: :SL HH:MM:SS#
Response: "1"

Sets the current local time. Must be issued in order for the calibrate mount command to be accepted. Command may be issued in long or short format regardless of whether long format has been selected.

Command: :SC MM/DD/YY#
Response 16 spaces followed by "#", followed by 16 spaces, followed by "#"

Sets the current date. Note that year fields equal to or larger than 97 are assumed to be 20th century, Year fields less than 97 are assumed to be 21st century. Must be issued in order for the calibrate mount command to be accepted.

Command: :GG#
Response: sHH

Gets the offset from Greenwich mean time.

Command: :Gg#
Response: DDD*MM# or DDD*MM:SS# if long format

Gets the current longitude.

Command: :Gt#
Response: sDD*MM# or sDD*MM:SS# if long format

Gets the current latitude.

Command: :GL#
Response: HH:MM.S# or HH:MM:SS# if long format

Gets the current local time.

Command: :GS#
Response: HH:MM.S# or HH:MM:SS# if long format

Gets the current sidereal time.

Command: :GR#
Response: HH:MM.S# or HH:MM:SS# if long format

Gets the current Right Ascention.

Command: :GD#
Response: sDD*MM# or sDD*MM:SS# if long format

Gets the current Declination.

Command: :CM#
Response: "Objects Coordinated#"

Calibrate mount. Current Right Ascension and Declination become the commanded Right Ascension and Declination respectively. This command must precede the first :MS# because it enables slewing motion. This command will be ignored if any one or more of the following has not been set since powerup: offset from Greenwich, latitude, longitude, local time, date, commanded RA, or commanded DEC.

Command: :Mn# :Ms# :Me# :Mw#
Response: (none)

Command motion in the direction specified (n=north, s=south, e=east, w=west) the currently selected guide or centering rate. Motion will continue until a quit command is issued.

Command: :MS#
Response: "0" if command accepted,
(none) if command not accepted,
"1Object is below horizon.
#" if the horizon check is turned on, and the desired object is below 0 degrees altitude.

Slew to the most recently defined RA and DEC coordinates. A calibrate mount command must have been previously issued else this command is ignored. Slewing is performed at the currently selected slew rate. If the horizon check is turned on, and the object is below the horizon, this will be annuciated, and no slewing will occur.

Command: :Qn# :Qs# :Qe# :Qw#
Response: (none)

Stop motion in the specified axis. Note that :Qn# is identical to :Qs#, and :Qe# is identical to :Qw#. Motion is terminated only if it was not started by a slew (:MS#) command.

Command: :Q#
Response: (none)

Motion in both axis is stopped, regardless of how the motion was invoked.

Command: :P#
Response: “HIGH PRECISION#” or “LOW PRECISION#”

Inquire format. If long format has been set on the communication port currently receiving the :P# command, then “HIGH PRECISION#” is returned. If long format has not been selected, then “LOW PRECISION#” is returned. This command has a slightly different function than described in the Meade protocol.

Command: :U#
Response: (none)

Select long format, valid only for the communication port through which this command is issued, ports are controlled independently. Unlike the Meade definition, though, once long format has been selected it cannot be deselected without powering down the unit. Only the first occurrence of :U# acts upon the port in question. Long format only defines the format of the return strings, Input data (using the set command) will be recognized in any format whether or not long format has been selected.

Command: :B+# :B-#

Response: (nothing)

Incrementally increases (B+) or decreases (B-) reticle brightness. Command to be sent over RS-232 each time a button is pressed to increase or decrease brightness. When the brightness is at the maximum, subsequent :B+# commands are ignored. When the brightness is at the minimum, subsequent :B-# commands are ignored. On powerup, the brightness is at the minimum (off).

The Meade commands :B0# :B1# :B2# :B3# are not implemented.

Command: :F+# :F-# :FF# :FS# :FQ#
Response: (nothing)

Advances (F+) or retracts (F-) focus adjust motor on the eyepiece. F+ or F- commands commence adjustment and :FQ# stops it. This works the same way the N-S-E-W keypad works (it may even be an operating mode of the same keys). If :FS# has been issued previously, then the focus adjustment will be slow. If the :FF# command has been issued, then the adjustment will be fast. If neither FF nor FS is specified, the powerup default of FS is assumed.

Command: :RG# :RG0# :RG1# :RG2#
Response: (nothing)

Selects guide rate for the N-S-E-W buttons. Optionally selects 0.25x (:RG0#), 0.5x (:RG1#), or 1.0x (:RG2#). If no index is provided (;RG#), the previously selected guide rate will be used, else the power up default of 0.5x will be assumed by the motor drive. The indexes are extensions of the Meade protocol.

Command: :RC# :RC0# :RC1# :RC2# :RC3#
Response: (nothing)

Selects centering rate for the N-S-E-W buttons. Optionally selects a rate of 12x (:RC0#), 64x (:RC1#), 600x (:RC2#), or 1200x (:RC3#). If no index is provided (:RC#), then the previously selected speed will be used, else the power up default of 64x will be assumed by the motor drive. The indexes are extensions of the Meade protocol.

Command: :RS# :RS0# :RS1# :RS2#
Response: (nothing)

Selects the slew speed used by the telescope move functions. This command has no effect on the use of the N-S-E-W buttons (therefore, :RS# has no effect). The default slew speed is 1200x. Slewing can be done at 1200x (:RS2#), 900x (:RS1#), or 600x (:RS0#). The indexes are extensions of the Meade protocol.

Non Meade commands:

Command: :RT0# :RT1# :RT2#
Response: (nothing)

This command selects the tracking rate. It selects lunar (:RT0#), solar (:RT1#), or sidereal (:RT2#). The sidereal rate is assumed as a default by the motor drive if nothing is specified. This command has no effect on the use of the N-S-E-W buttons. This command is not in the Meade manual.

Command: :NS#
Response: (nothing)

This command swaps the functions of the north and south buttons. Subsequent commands :Mn# and :Ms# are affected. This command is not in the Meade manual.

Command: :EW#
Response: (nothing)

This command swaps the functions of the east and west buttons. Subsequent commands :Me# and :Mw# are affected. This command is not in the Meade manual.

Command: :p# :pR# :pP#
Response: (currently none)

This command either invokes PEM record mode (:pR#), invokes PEM playback mode (:pP#), or turns playback off (:p#). The record function will remain active for one full revolution of the worm gear and cannot be terminated. If :p# or :pP# is received during record, it will be ignored. The time required for a record cycle depends upon which mount is used and how much correction is applied. Commands to slew will be ignored during record. Commands to select centering speed will become active only after the record cycle has completed.

When playback is selected, it remains active until turned off. Playback is also temporarily turned off when a command to slew is issued or any of the N-S-E-W buttons are pressed. It is automatically reinvoked when the commanded position has been reached and none of the N-S-E-W buttons are pressed. This command is not in the Meade manual.

Command: :Bd DD*MM:SS# :Br DD*MM:SS#
Response: "1"

This command sets the amount of backlash compensation employed each time a servo motor axis reverses direction. Bd sets the backlash of the DEC axis, Br sets the backlash of the RA axis. Resolution of the backlash is in arc seconds. Typically, the degrees and minutes fields are zero to specify the amount of backlash only in seconds. Values of backlash above 00*54:36 may be truncated, depending upon which mount is used (this is a ridiculously large value, typical values should be well under 00*01:00). The default DEC backlash is 00*00:00, the default RA backlash is 00:00:15 (same as 00*03:50). Backlash in either axis will be properly interpreted whether expressed as DD*MM:SS or HH:MM:SS. This command is not in the Meade manual.

Command: :ho# :hq#
Response: (currently none)

This command turns on (:ho#) and off (:hq#) the horizon check. The horizon check, when turned on, is performed when a "goto" (or :MS#) is issued. If the coordinates define a location below zero degrees altitude, then the string "1Object is below horizon. #" is returned instead of "0". No compensation of coordinates for atmospheric refraction is made. On powerup, the horizon check is off since it is currently performed in the handheld controller, Digital Sky, and The Sky.

Command: :de# :dn#
Response: (currently none)

This command invokes the data feedthrough function between COM 1 and the handheld controller. The purpose is to allow software and database updates to the handheld controller, through the servo drive, without special connectors. For code downloads, :de# is used to provide transparent communications between COM 1 and the handheld unit with even parity. For database downloads, :dn# is used to provide transparent communications with no parity. Once either command is issued, normal operation (or parity change) can only be resumed by powering down the servo drive. COM 2 cannot be used

in the transparent mode. Once the pound sign of the command has been received by the servo drive, all subsequent bytes received from COM 1 or the handheld are reflected to the other. Data received on COM 2 is ignored, and no data is transmitted from COM 2.

Applicatons

Park Mode:

Park mode is invoked by setting the guide rate to 1x (:RG2#), and commanding the RA axis east (:Me#). This effectively stops the RA motor since tracking is done at 1x west. If the motor drive powers down in this condition, it recognizes this on the next powerup and stays in park. To terminate park mode and continue normal tracking, a quit command must be issued (:Q# or :Qe# or :Qw#). Park should not be invoked if a PEC record cycle is in progress.